

MONITORING PROGRAM ANNUAL REPORT

NOVEMBER 1997 - OCTOBER 1998

ANCHORAGE WATER AND WASTEWATER UTILITY POINT WORONZOF WASTEWATER TREATMENT FACILITY

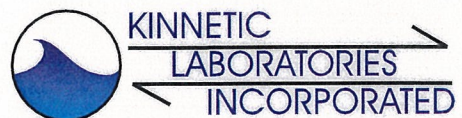


Prepared for:



MUNICIPALITY OF ANCHORAGE
Anchorage Water & Wastewater Utility
Anchorage, Alaska

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January 1999

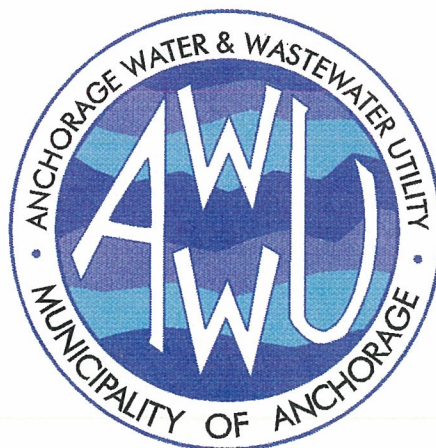
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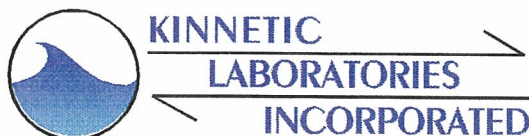
ANCHORAGE WATER AND WASTEWATER UTILITY POINT WORONZOF WASTEWATER TREATMENT FACILITY

NPDES Permit AK-002255-1
State I.D. AK850124-21A

Prepared for:



Prepared by:



with contract administration and technical review by

CH2MHILL

January 1999

PREFACE

This document is the thirteenth Monitoring Program Annual Report required for submittal to the Environmental Protection Agency by NPDES Permit AK-002255-1 for discharge from the John M. Asplund Water Pollution Control Facility, operated by the Municipality of Anchorage at Point Woronzof. The NPDES Permit incorporates provisions necessitated by a 301(h) waiver from the requirements of secondary treatment.

The elements of the Monitoring Program are:

- Influent, Effluent, and Sludge Monitoring
- Receiving Water Quality Monitoring
 - Plume Dispersion
 - Intertidal Zone Bacteria
- Biological and Sediment Monitoring
 - Intertidal Invertebrates
 - Subtidal Invertebrates
 - Bioaccumulation
 - Sediment Quality

During 1998, the program consisted of sampling the influent, effluent, and sludge twice for toxic pollutants and pesticides (once for Summer-wet and once for Summer-dry) and one receiving water quality sampling. In addition, the Municipality of Anchorage conducted the required monthly self-monitoring program for the influent, effluent, and sludge. No biological or sediment sampling was conducted during 1998.

This Annual Report covers the period 1 November 1997 through 31 October 1998.

CHAPTER 1

The first part of the chapter discusses the importance of the study of the history of the United States. It is a study of the past, but it is also a study of the present. The study of the past helps us to understand the present, and the study of the present helps us to understand the future.

The Importance of the Study of the History of the United States

1. The Study of the History of the United States is a Study of the Past, the Present, and the Future

The Study of the History of the United States is a Study of the Past

The Study of the History of the United States is a Study of the Present

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The Study of the History of the United States is a Study of the Past, the Present, and the Future

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- 2.0 Pesticides
- 3.0 Asbestos
- 4.0 Trace Metals and Cyanide
- 5.0 Hydrocarbons

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- 2.0 Hydrocarbons
- 3.0 Water Quality Parameters
- 4.0 Intertidal Zone Bacteria
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SUMMARY

PURPOSE

This report is submitted in response to requirements of the U.S. Environmental Protection Agency (EPA) and the Alaska Department of Environmental Conservation (ADEC) as outlined in the National Pollutant Discharge Elimination System (NPDES) Permit AK-002255-1. This Permit authorizes discharge of effluent from the John M. Asplund (Point Woronzof) Water Pollution Control Facility. Wastewater from the Municipality of Anchorage (MOA) is treated at this facility before discharge to the receiving waters of Knik Arm in Cook Inlet, Alaska. The NPDES Permit incorporates the requirements necessitated by a 301(h) waiver from secondary treatment and is in compliance with provisions of the Federal Water Pollution Control Act as amended by the Clean Water Act (33 U.S.C. §1251 et seq.).

HISTORY

In September 1979, the MOA submitted to the EPA a 301(h) secondary treatment waiver application proposing an improved discharge which eliminated chlorination and required the addition of both a 610-m extension and a 305-m diffuser to the Point Woronzof outfall. The outfall extension was intended to move the point of discharge beyond the influence of a gyre that was reported to exist off Point Woronzof on a flood tide which was presumed to carry effluent toward shore, causing bacterial contamination of the shoreline.

Further studies were subsequently undertaken to derive design criteria for the outfall improvements. The central issue was to evaluate outfall design alternatives and the chlorination/no chlorination option in relation to a system of eddies that occur on the flood tide. These studies were completed and presented as an *Amendment to the Wastewater Facilities Plan for Anchorage, Alaska* (CH2M Hill *et al.*, 1985). This amended plan recommended the use of the existing 245-m outfall with the addition of a three-nozzle diffuser. It was shown that chlorination would be required to meet bacterial standards even with an extended outfall and diffuser. Because the same water quality standards could be met by chlorinating and installing an improved diffuser at the end of the existing outfall, there was no need to extend the outfall.

Concurrent with the studies to amend the facilities plan, a revised 301(h) waiver application was submitted to the EPA. After extensive EPA review, public comment, and hearings, the Final Permit Decision was issued and the five-year NPDES Permit became effective 16 October 1985. The Permit specifies the required monitoring program. As required by this Permit, a multi-port diffuser was installed in August 1987 prior to the second year of receiving water sampling.

During April 1990, the Municipality submitted to EPA an application for a new 301(h) waiver from secondary treatment. A more recent application was submitted in 1998. Decision on the application is still pending. At the present time, the Municipality is operating under an extension of their five-year Permit issued in 1985.

RECEIVING WATER ENVIRONMENT

The Knik Arm into which the Point Woronzof facility discharges is a unique estuarine body of water with extremely high tidal fluctuations (up to 11.6 meters [m] with a mean range of 7.89 m at Anchorage; NOAA/NOS, 1995). These fluctuations produce extensive tidal flats, swift tidal currents of 4-5 knots, and intense mixing within the Inlet. The water is almost a slurry because of the naturally high suspended sediment concentrations of up to 2500 mg/L. This sediment originates from glacial melt waters discharging into Cook Inlet.

Large temperature extremes occur between summer and winter. In the winter, ice can reach thicknesses of one to two m and consists of broken pieces due to the large tides and currents. Other important factors are the large volume of saline water present in Cook Inlet and mixing by tidal turbulence which allows this volume to be effective in wastewater dilution and assimilation.

MONITORING OBJECTIVES

The monitoring that was conducted during 1998 consisted of two main components: (1) in-plant monitoring of influent, effluent, and sludge; and (2) receiving water quality monitoring in the vicinity of the discharge and at a control site across Knik Arm. Objectives of the 1998 program are summarized as follows:

1998 MONITORING OBJECTIVES

- | | |
|-----------------------------------|---|
| Influent, Effluent,
and Sludge | <ul style="list-style-type: none">• Monitor plant performance• Characterize toxic substances• Determine effectiveness of industrial pretreatment program• Aid in assessing water quality at discharge point• Determine compliance with NPDES Permit and water quality criteria |
| Water Quality | <ul style="list-style-type: none">• Determine compliance with NPDES Permit, State and Federal water quality standards, and regulatory criteria of Section 301(h) of the Clean Water Act• Determine level of bacterial concentration in nearshore waters• Assess adequacy of total residual chlorine effluent limitation |

MONITORING RESULTS

As part of its self-monitoring program, the Anchorage Water and Wastewater Utility (AWWU) conducted daily, weekly, and monthly sampling of influent, effluent, and sludge, depending on the parameter measured. In addition, monitoring for toxic pollutants and pesticides was conducted twice during 1998. Water quality monitoring in the vicinity of the discharge was conducted once during the summer of 1998. The following summarizes results from the thirteenth year of monitoring:

1998 MONITORING RESULTS

Influent, Effluent, and Sludge

- Met Permit objectives and requirements and Alaska State water quality standards with few exceptions. Results from parameters of particular concern are summarized below, including Permit exceedences as noted.
- Total hydrocarbons as measured by SM 503B, exceeded the Maximum Allowable Effluent Concentration (MAEC) for the "growth and propagation of fish, shellfish, aquatic life, and wildlife" during both of the toxic pollutant samplings. The high concentrations of total hydrocarbons measured by this method is mainly due to the fact that they are oil and grease methods rather than hydrocarbon test methods. The State specified total hydrocarbon method has been replaced by more appropriate methods in the new State of Alaska water quality standard regulations that were put into effect 16 March 1996. Use of these more appropriate methods indicated that the Point Woronzof effluent met the MAEC for total aqueous hydrocarbons and that effluent hydrocarbon concentrations were not a concern.
- Total aromatic hydrocarbon concentrations measured in the effluent were below the allowable MAEC during all samplings.
- Cyanide and heavy metals concentrations in the effluent never exceeded their MAECs during any of 1998 monthly or toxic pollutant samplings.
- MOA's self-monitoring of flow rate and pH showed compliance with Permit effluent limitations. Daily and monthly maxima for total residual chlorine in the effluent were never exceeded. Total suspended solids were well within the daily, weekly, and monthly criteria for the entire reporting period. Fecal coliform concentrations met both the monthly criteria of "not more than 10% of the samples shall exceed 2600 FC MPN/100 mL during any month" and the geometric mean of less than 850 FC/100 mL. Fecal coliform concentrations in the effluent were the lowest in 1998 than those reported since the initiation of the Permit.
- The BOD₅ daily maximum criterion of 140 mg/L was exceeded three times during the reporting period. The weekly average BOD₅ criteria of 130 mg/L was never exceeded, and the monthly average criteria of 120 mg/L was exceeded once during the reporting period.
- Priority pollutant influent and effluent concentrations were within the established range or lower than values from a national study of secondary treatment plants.
- Toxic pollutant sludge concentrations were within the established range or lower than values from a national study of secondary treatment plants.
- BOD₅ and total suspended solid removals were substantially better than the 30% required by the 1987 Amendment to the Clean Water Act.

1998 MONITORING RESULTS (continued)

Water Quality

- Little variation among stations was observed.
- Intertidal fecal coliform concentrations along the beaches near Point Woronzof met the most restrictive State water quality criteria median of 14 FC/100 mL for "harvesting for consumption of raw mollusks or other raw aquatic life". Since the Cook Inlet is unclassified under ADEC's water quality standard, the most restrictive criteria apply, although no shellfish beds exist in the vicinity. The criterion of not more than 10% of the samples exceeding 40 FC 100/mL was also met. The fecal coliform concentrations in area creeks exceeded those from intertidal stations.
- Fecal coliform concentrations were significantly higher in the outfall area as compared to the control stations. Receiving water samples met the State-specified criterion of a median of 14 FC/100 mL, but the criterion of not more than 10 percent of the samples exceeding 40 FC/100 mL could not be assessed. Local creeks exhibited fecal coliform concentrations higher than all water quality and intertidal stations.
- Enterococci bacteria counts were also significantly different between the intertidal outfall and control areas, although enterococci counts were relatively low. Local creeks exhibited counts higher than all water quality and intertidal stations.
- Total recoverable metals for copper, mercury, and nickel exceeded receiving water criteria at both control and outfall stations. All dissolved metals concentrations were below water criteria. With the exception of dissolved arsenic, copper, nickel, and lead, no significant differences between the outfall and control stations were found for either dissolved or total recoverable metals. Total cyanide concentrations at all stations were below detection limits.
- Total aqueous hydrocarbons, measured as aliphatic hydrocarbons, total aromatic hydrocarbons (EPA Method 602), and total PAH met the State's water quality standards at all stations. No significant differences were found between concentrations at the control and outfall stations for any hydrocarbon analyses except for two sterols that are indicative of human wastes.
- Turbidity exceeded the State water quality criteria of 25 NTUs at all stations and all depths; this is attributed to the naturally high suspended sediment concentrations in Cook Inlet. Color exceeded the State water quality criterion of 15 color units on one sample on the mixing zone boundary; this value was attributed to turbidity interferences.

CONCLUSIONS

Results from the thirteenth year of the expanded monitoring program confirm previous studies, data in the 301(h) waiver application, and the decision by the EPA to issue the Permit. The Point Woronzof facility, with few exceptions, is operating within regulatory requirements with no significant impacts to the marine environment. Ongoing and future monitoring results are expected to be consistent with results from the first thirteen years of the program.

1.0 INTRODUCTION

1.1 REGULATORY/ENVIRONMENTAL BACKGROUND

The Point Woronzof Monitoring Program is designed to meet the requirements of the National Pollutant Discharge Elimination System (NPDES) Permit AK-002255-1 which authorizes discharge of municipal effluent into the Knik Arm of Cook Inlet receiving waters from the John M. Asplund Water Pollution Control Facility, operated by the Municipality of Anchorage (MOA), Figure 1. The NPDES Permit, which became effective on 16 October 1985, incorporates the requirements necessitated by a 301(h) secondary treatment waiver and is in compliance with provisions of the Federal Water Pollution Control Act as amended by the Clean Water Act (33 U.S.C. §1251 et seq.).

1.1.1 Regulatory Background

In 1972, while the Point Woronzof treatment facility and outfall were being built for the MOA, the Federal Water Pollution Control Act (FWPCA) was amended to establish two phases of effluent limitations applicable to all Publicly Owned Treatment Works (POTWs). Under 301(b), POTWs were required to achieve secondary treatment of effluent by 1 July 1977 and the "best practicable waste treatment technology" by July 1983.

Congress again amended the FWPCA in 1977. Section 301(h) was added, providing that the Administrator of the U.S. Environmental Protection Agency (EPA), upon application from a POTW and with the concurrence of the State, might issue an NPDES Permit waiving the requirements of Section 301(b). On 15 June 1979, EPA promulgated the regulations regarding the issuance of this waiver of secondary treatment to an applicant discharging into certain ocean and estuarine waters and demonstrating compliance with the 301(h) criteria.

In September 1979, the MOA forwarded to EPA a 301(h) waiver application proposing an improved discharge which eliminated chlorination and required the addition of both an extension and diffuser to the Point Woronzof outfall. Earlier studies had recommended the construction of a 610-m outfall extension and a 305-m diffuser. The proposed extension/diffuser reportedly could meet fecal coliform receiving water standards without chlorination and prevent shore contact of the wastewater plume.

As a parallel program, the MOA undertook preparation of a wastewater master plan for the Anchorage Bowl area. The resultant *Wastewater Facilities Plan for Anchorage, Alaska* (Ott Water Engineers, Inc. et al., 1982) and the *Environmental Impact Statement, City of Anchorage, Alaska, Wastewater Facilities* (EPA and Jones & Stokes, 1982) were accepted by the EPA and the Alaska Department of Environmental Conservation (ADEC).

Further studies were subsequently undertaken to derive design criteria for the outfall improvements. Significant efforts were included in this study to improve the reconnaissance level data upon which the outfall length and diffuser design were to be based and to evaluate bacterial standards applicable to Knik Arm. The central issue was to evaluate outfall design alternatives and the chlorination or no-chlorination option in relation to the presence of a system of eddies that occur to the east of Point Woronzof on the flood tide and that might be capable of transporting the effluent shoreward.

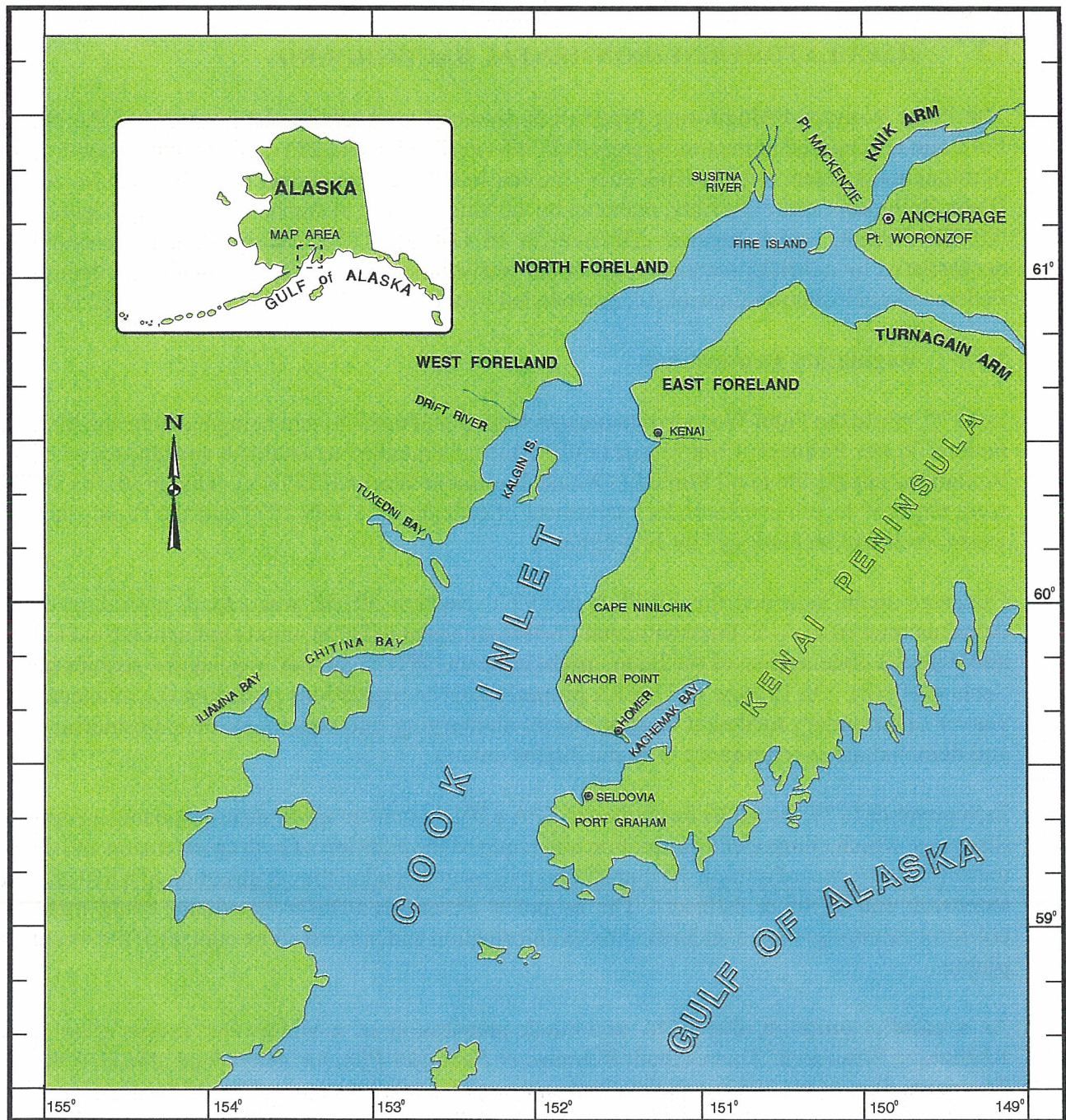


Figure 1. General Study Area.

These latter studies were completed and presented as an *Amendment to the Wastewater Facilities Plan for Anchorage, Alaska* (CH2M Hill *et al.*, 1985). This amended plan recommended use of the existing 245-m outfall with the addition of a three-nozzle diffuser. It was shown that chlorination would be required to meet bacterial standards even with an extended outfall and diffuser. Because the same standards could be met by use of chlorination and the existing outfall, there was no need to extend the outfall. With continued chlorination, all water quality standards were predicted to be met by the amended plan.

Concurrent with the studies to amend the facilities plan, a revised application entitled *Application for Modification of Secondary Treatment Requirements, Section 301(h), Clean Water Act* was submitted to EPA (CH2M Hill *et al.*, 1984). The EPA Region X 301(h) Review Team's Tentative Decision Document, entitled *Analysis of the Section 301(h), Secondary Treatment Variance Application for the John M. Asplund Water Pollution Control Facility* (EPA, 1985c), and a draft NPDES Permit were made available for public comment on 17 January 1985. After comments and appropriate hearings, the Final Permit Decision (EPA, 1985d) was issued 13 September 1985, and the start date of the five-year NPDES Permit AK-002255-1 was listed as 16 October 1985. As required by this Permit, a multi-port diffuser was installed at the Point Woronzof outfall in the beginning of August 1987. This occurred prior to the 1987 Summer water quality monitoring program.

The NPDES Permit specified the required monitoring program. The *Monitoring Program Plan* (CH2M Hill *et al.*, 1986), submitted to the EPA in January 1986, identified how the MOA plans to fulfill the requirements of this program. This report documents the progress and results of the monitoring program during the thirteenth year under the Permit.

1.1.2 Environmental Background

The John M. Asplund Water Pollution Control Facility discharges to the receiving waters of Cook Inlet, Alaska. The discharge is located off Point Woronzof in Knik Arm of Upper Cook Inlet.

Cook Inlet is a major tidal estuary that is approximately 333 km (180 nautical miles) long and 93-148 km (50-80 nautical miles) wide at its lower end. Bathymetry indicates the Inlet is deep, generally 36.6 m (20 fathoms) north of the Forelands and about 164.6 m (90 fathoms) at the mouth. Numerous rivers, including the major Susitna River drainage, discharge into the Inlet. A detailed map of the Point Woronzof region indicates deep water (9.1-51.8 m) extending well past Anchorage up the Knik Arm (Figure 2).

Cook Inlet is a unique estuary, with perhaps the closest parallel being the Bay of Fundy between New Brunswick and Nova Scotia, Canada. The occurrence of tidal bores at the head, currents of 4-5 knots, suspended loads of up to 2500 mg/L, large temperature extremes, and moving pancake ice of up to one m thick make Cook Inlet unique. The high tidal ranges result from the geometry of the Inlet which has a natural resonance period close to the semi-diurnal tidal period. The resulting large tidal currents cause complete vertical mixing of the Inlet waters.

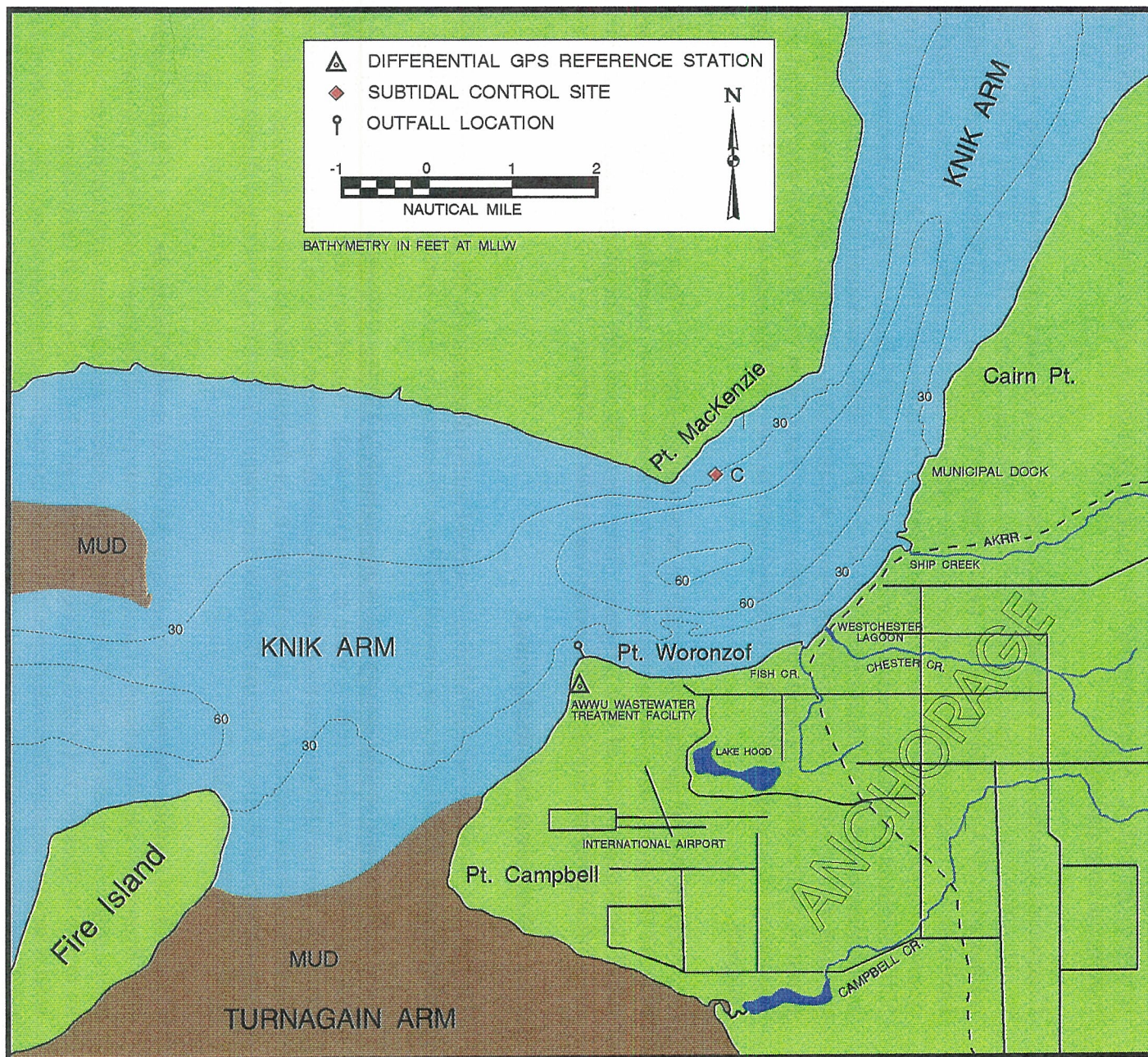


Figure 2. Point Woronzof Outfall, Differential GPS Station and Control Station Locations.

In addition to these features, two other factors are important to this study. They are the very large volume of saline water present in the Inlet and the degree of mixing achieved by the tidal turbulence which allow these volumes to be effective in wastewater dilution and assimilation.

The particle size distribution of the natural suspended sediments off Point Woronzof show that very large particles are suspended by the current-generated turbulence, with 50 percent of the load being in the size range of 65-250 microns. The settling of large particles is seen in the Inlet at slack tide. Settling rate tests of the suspended material show that 93 percent of the solids in the ambient water sample settle in twenty minutes.

Previous work has indicated that due to the extremely swift currents, no seabed accumulation of suspended sediments, either natural or from the discharge, occur in the vicinity of the outfall. In this location, the bottom is strictly coarse gravel and cobble because of these currents. However, areas of deposition do exist, such as to the east of Point Woronzof, where mudflats and beaches are found and to the southwest of the Point. The area between Fire Island and the mainland is hard-packed sand with no deposition of silt or finer materials as a result of the high current energy. Silt sedimentation is a difficult problem at the Port of Anchorage where the Corps of Engineers conduct annual dredging operations. Of course, any settleable solids in these materials of effluent origin would be diluted by the much larger natural load in the receiving water (400-2,500 mg/L versus less than 1 mg/L effluent).

Studies have also shown that essentially no benthic biota are found on the scoured cobble/gravel bottom or on the rock beaches at Point Woronzof and the control area. Similar sampling of soft bottom beaches and tidal flats showed very sparse abundances and very low diversities. The harsh physical environment of silt, turbulence, currents, tides, and ice limit benthic and intertidal marine fauna populations.

Current trajectories in the immediate vicinity of the outfall are of concern because of flow separation zones on either side of Point Woronzof. Previous work has indicated that, on a flood tide, a clockwise system of eddies exist east of Point Woronzof. These eddies may result in the shoreward transport of wastes at certain stages of tide. A flow separation also exists to the west of Point Woronzof during ebb flow, however the effluent is not entrained shoreward in this area.

1.2 SUMMARY OF PROGRAM COMPONENTS

The Point Woronzof Monitoring Program specified in the NPDES Permit AK-002255-1 consists of monitoring: (1) plant and discharge constituents; (2) receiving water quality; and (3) the biological/sediment environment in the vicinity of the discharge.

1.2.1 Influent, Effluent, and Sludge Monitoring

The objectives of influent monitoring were to characterize influent toxic substances and to provide data for monitoring plant performance, toxic substances control, and the effectiveness of the MOA's industrial pretreatment program. Additionally, it was to satisfy, in part, the regulatory requirements of the Code of Federal Regulations, Title 40 (40 CFR) Part 125.62, which states that all dischargers receiving a 301(h) waiver shall determine compliance with NPDES Permit terms and conditions.

The objectives of effluent monitoring were to characterize effluent toxic substances; determine fecal coliform and enterococci bacteria concentrations; and provide data for monitoring plant performance, toxic substances control, and receiving water quality for evaluating the reissuance of the NPDES Permit. Effluent monitoring was included in the Monitoring Program Plan to satisfy, in part, the three regulatory requirements of 40 CFR 125.62. These are that dischargers receiving a 301(h) waiver shall:

- Document short- and long-term effects of the discharge on the receiving waters, sediments, biota, and beneficial uses of the receiving waters.
- Assess the effectiveness of toxic control program.
- Determine compliance with the NPDES Permit.

The objectives of sludge monitoring were to characterize the toxic substances in the sludge and monitor plant performance. Additionally, sludge monitoring would provide data for evaluating reissuance of the NPDES Permit. Part 503 of the Sludge Regulations (40 CFR) published 19 February 1993 requires the monitoring and reporting of certain metals effective 19 July 1993, and this will be required under a new NPDES permit.

The monitoring requirements for influent, effluent, and sludge are outlined in Tables 1 and 2. These parameters, with the exception of toxic pollutants, pesticides, and enterococci bacteria, were reported monthly by the Point Woronzof Laboratory.

1.2.2 Water Quality Monitoring

The Water Quality Monitoring task contains two elements: (1) plume dispersion sampling and (2) intertidal zone bacterial sampling.

1.2.2.1 Plume Dispersion Sampling

The objective of plume dispersion sampling was to determine compliance with applicable State and Federal water quality standards and the regulatory criteria of Section 301(h) of the Clean Water Act. Compliance with appropriate receiving water standards was determined at the edge of the Zone of Initial Dilution (ZID) or State mixing zones for total residual chlorine and fecal coliform, as appropriate.

Because of the extremely swift currents within the Knik Arm receiving waters, water quality stations were taken adjacent to floating drogues. This approach was specified for the following reasons:

- Difficulties were expected in safely anchoring the vessel for the number of times required. In addition, high wire angles and attendant equipment handling problems in swift current were anticipated.

Table 1. Influent, Effluent, and Sludge Monitoring Requirements.

Parameter	Sample Point	Sample Frequency	Sample Type
Temperature	influent	daily	grab
	effluent	daily	grab
pH	influent	daily	grab
	effluent	daily	grab
Flow	effluent	continuous	continuous
Total Residual Chlorine	effluent	continuous or every 2-4 hours	grab
Settleable Solids	influent	daily	grab
	effluent	daily	grab
Suspended Solids	influent	5/week ¹	24-hr composite
	effluent	5/week ¹	24-hr composite
Total Solids	sludge, prior to thickening	4/week ¹	grab
Alkalinity	effluent	monthly ²	grab
Fecal Coliform Bacteria	effluent, following chlorination	3/week ¹	grab
Enterococci Bacteria	effluent, following chlorination	whenever sampled in receiving water	grab
Oil and Grease	effluent	weekly ³	24-hr composite
Heavy Metals ⁴	influent	weekly ^{3,5}	24-hr composite
	effluent	weekly ^{3,5}	24-hr composite
	sludge	monthly ⁶	24-hr composite
Cyanide ⁷ (Total)	influent	weekly ^{3,5}	24-hr composite
	effluent	weekly ^{3,5}	24-hr composite
	sludge	monthly ⁶	24-hr composite
Toxic Pollutants and Pesticides ⁸	influent	4/year	24-hr composite
	effluent	4/year	24-hr composite
	sludge	2/year	24-hr composite
DO	effluent ⁹	daily	grab
BOD ₅	influent	4/week ¹	24-hr composite
	effluent	4/week ¹	24-hr composite

Table 1. Influent, Effluent, and Sludge Monitoring Requirements. (continued)

Footnotes:

1. Sampling shall be arranged so that each day of the week is represented each month. Periodic weekend sampling shall continue throughout the Permit term. However, weekend sampling may be reduced if the permittee demonstrates to the satisfaction of the Director, that such a reduction will still meet objectives (1) and (5) in Part I.B.1. In April 1990, BOD sampling was reduced to Monday through Thursday only, Total Suspended Solids (TSS) sampling was reduced to five days a week only (Sunday through Thursday), and the requirement for testing solids on sludge prior to thickening was eliminated by EPA.
2. Alkalinity shall be sampled only between July and December and only in Year 1 of the Permit.
3. Sampling shall be arranged so that each day of the week is represented each quarter (or each year, if the monitoring frequency is reduced to monthly). Periodic weekend sampling shall continue throughout the Permit term. However, weekend sampling may be reduced if the permittee demonstrates, to the satisfaction of the Director, that such a reduction will still meet objectives (1) and (5) in Part I.B.1.
4. Heavy metals includes As, Cd, Cu, Pb, Hg, Ni, Ag, Zn, and Total Chromium. Values for each metal shall be reported as "total" (not "total recoverable").
5. Heavy metals and cyanide will be monitored weekly during Years 1 and 4 of the Permit and monthly during Years 2, 3, and 5 through 13 inclusive. Each year, the permittee shall address, to the satisfaction of the Director, whether monthly sampling is adequate to meet objectives (1) and (5) in Part I.B.1. If monthly sampling does not meet these objectives, weekly sampling shall be required.
6. Samples shall be collected on a day when influent and effluent are sampled.
7. Cyanide samples are three grabs, taken eight hours apart, preserved immediately and then composited after flow weighting.
8. Samples for toxic pollutants and pesticides shall be composites of hourly grabs collected during four periods (Winter-dry weather; Spring breakup-wet or dry weather; Summer-wet weather; and Summer-dry weather) in Years 1 and 4, and in Summer (wet and dry weather) in Years 2, 3 and 5 through 13 inclusive (Part I.B.7.a.[1]). The sampling frequency may be increased by the Director (Part I.B.7.a.[2]). Total hydrocarbons and total aromatic hydrocarbons shall be computed and reported for each effluent sample.
9. Sampling point for Dissolved Oxygen (DO) was switched from primary to final effluent in April 1990.

Table 2. Toxic Pollutant, Pesticide, and Enterococci Bacteria Monitoring Requirements.

Parameter	Frequency	Sample Type	Remarks
INFLUENT			
Toxic Pollutants and Pesticides	4/year	24-hr composite	Time-proportional composites during: <u>Years 1 and 4</u> Winter-dry weather Spring breakup-wet or dry Summer-wet Summer-dry
	2/year		<u>Years 2, 3, and 5 through 13 inclusive</u> Summer-wet Summer-dry
EFFLUENT			
Enterococci Bacteria	Whenever sampled in receiving water	grab	Final Effluent
Toxic Pollutants and Pesticides	4/year	24-hr composite	Time-proportional composites during: <u>Years 1 and 4</u> Winter-dry weather Spring breakup-wet or dry Summer-wet Summer-dry
	2/year		<u>Years 2, 3, and 5 through 13 inclusive</u> Summer-wet Summer-dry
SLUDGE			
Toxic Pollutants and Pesticides	4/year	24-hr composite	Composites of hourly grabs during: <u>Years 1 and 4</u> Winter-dry weather Spring breakup-wet or dry Summer-wet Summer-dry
	2/year		<u>Years 2, 3, and 5 through 13 inclusive</u> Summer-wet Summer-dry

- Because ambient flow patterns varied greatly during any given tidal cycle, sets of station data (outfall, ZID boundary, nearfield) must be sampled several times during each tide stage. Thus, quick sampling was necessary, which was precluded by the necessity of anchoring.

The plume locations were followed by using holey-sock drogues. Drogues were deployed at the outfall during both flood and ebb tides and during flood tides at the control site. Water quality at the outfall was sampled at a minimum of three stations along the drogue's track. These regions were:

- Within the ZID (less than 25 m from the diffuser location). The diffuser is at latitude $61^{\circ} 12' 22.5''$ North, longitude $150^{\circ} 01' 08.7''$ West (Station IT-0).
- As near the ZID boundary as practicable on the down-current side of the diffuser. The ZID boundary was sampled at a distance of 25 m from the diffuser and not exactly at the ZID boundary as defined in the Permit.
- The nearfield area outside the mixing zone, along the drogue's path or where it grounds at the end of its path.
- In addition to the three water quality stations, a fourth station for fecal coliform and enterococci bacteria was monitored at a point in the far-field along the first drogue track of each tidal cycle.

The ZID is defined by a square, 28.5 m on a side, with a corner 32.5 m beyond the center part of the diffuser. The opposite corner is 7.8 m behind the center part, and the diagonal is coincident with the line of the outfall. The ZID includes the water column above this square. The ADEC designated the mixing zone for residual chlorine as a circle with a radius of 600 m and the mixing zone for fecal coliform as a circle with a radius of 245 m.

Three releases were conducted during a flood tide at a control site on the day subsequent to the successful drogue releases at the diffuser stations. The control station was located across Knik Arm near Point MacKenzie (Station C, Figure 2) in an area believed to be representative of the flow separation region north of Point Woronzof. These areas were of interest because of potential receiving water/beach impacts. The coordinates of the control station are $61^{\circ} 14' 23.8''$ North and $149^{\circ} 57' 39.8''$ West. Three regions were sampled along each drogue path, including the original release location and the area immediately seaward of the drogue grounding site or after the drogue had traveled north of Cairn Point.

Profile and grab samples were collected at each sampling position along each drogue track. The following information was collected at each position:

- Surface samples (0.5 m) depth
 - Fecal coliform bacteria
 - Enterococci bacteria
 - Color
 - Total residual chlorine

- Aromatic hydrocarbons; polycyclic aromatic hydrocarbons; aliphatic hydrocarbons; total suspended solids; dissolved and total recoverable metals; and cyanide. Samples were obtained at the first three stations along the first flood drogue drop at both the outfall and control stations.
- Profiles (at 1 to 3 m intervals depending on water depth and safety but a minimum of three depths, where practicable)
 - Dissolved Oxygen
 - pH
 - Salinity
 - Temperature
- Water quality parameters [at the top (0.5 m), middle, and bottom (bottom 1 m) of the water column]
 - Dissolved Oxygen
 - pH
 - Turbidity
- Visual Observations - At each station noted the presence or absence of:
 - Floating solids
 - Visible foam
 - Visible oily sheen
- Meteorological conditions described as follows:
 - Clear (no clouds at any level)
 - Partly cloudy (scattered/broken)
 - Continuous layer(s) of clouds
 - Blowing snow/dust
 - Fog/haze
 - Drizzle
 - Rain
 - Snow or rain/snow mixed
 - Showers
 - Thunderstorm
 - High winds
 - Tide

The Point Woronzof Water Quality Monitoring Program schedule is as follows:

Year 1 (1986):	Spring, Summer, and Fall
Year 2 (1987):	Summer
Year 3 (1988):	Summer
Year 4 (1989):	Spring, Summer, and Fall
Year 5 (1990):	Summer
Year 6 (1991):	Summer
Year 7 (1992):	Summer
Year 8 (1993):	Summer

Year 9 (1994): Summer
 Year 10 (1995): Summer
 Year 11 (1996): Summer
 Year 12 (1997): Summer
 Year 13 (1998): Summer

1.2.2.2 Intertidal Zone Bacterial Sampling

The objectives of this program were to determine if bacterial contamination occurs in the Inlet's nearshore water and to determine the adequacy of the total residual chlorine effluent limitation for protecting water quality. Eight intertidal stations plus Station IT-0 (at the diffuser) were sampled as described below. The sampling locations are shown in Figure 3.

<u>Station</u>	<u>Location</u>	<u>Latitude (N)</u>	<u>Longitude (W)</u>
IT-0	above the diffuser	61° 12' 22.5"	150° 01' 08.7"
IT-1	250 m E-SE	61° 12' 19"	150° 00' 52"
IT-2	750 m E	61° 12' 15"	150° 00' 20"
IT-3	1200 m E	61° 12' 11"	149° 59' 50"
IT-4	2000 m E	61° 12' 10"	149° 58' 55"
IT-5	250 m S	61° 12' 15"	150° 01' 10"
IT-6	750 m SW	61° 12' 02"	150° 01' 28"
IT-7	2000 m SW	61° 11' 22"	150° 02' 02"
IT-C4	control across Inlet	61° 15' 12"	149° 57' 02"

1.2.3 Biological and Sediment Monitoring

The biological and sediment monitoring program is comprised of three elements: intertidal and subtidal invertebrate fauna sampling; intertidal and subtidal sediment chemistry sampling; and bioaccumulation sampling. The first two elements were conducted during Years 1 and 4 of the program, and the third element was conducted during Years 2 and 4 of the program. No biological or sediment sampling was conducted during the thirteenth year of sampling.

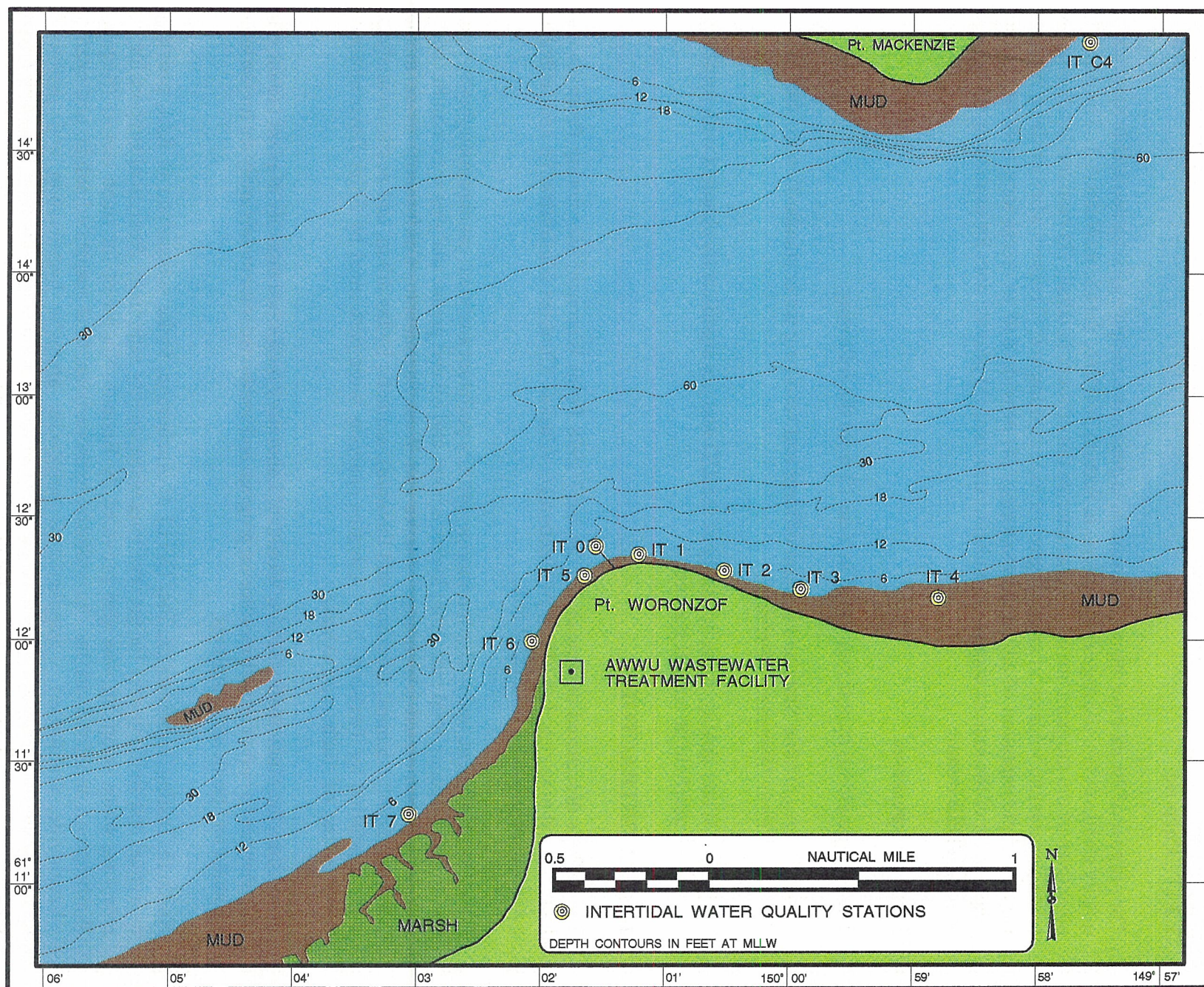


Figure 3. Station Locations for Bacterial Sampling.

1.3 STUDY DESIGN

1.3.1 Purpose

The purpose of the monitoring requirements is to determine compliance with applicable State water quality standards and the regulatory criteria in Section 301(h) of the Clean Water Act. The primary objectives of the program are to: (1) characterize the effluent in detail; (2) monitor for discharge-related ecosystem impacts in areas of greatest expected impact; (3) assess whether these impacts warrant implementation of adjusted monitoring; (4) provide data to assess long-term or gradual degradation of the marine ecosystem in Knik Arm; and (5) provide data for evaluating reissuance of the NPDES Permit.

1.3.2 Hypotheses

The null (no effect) hypotheses tested in Year 13 were the following:

- H₀1: Applicable State and Federal effluent and receiving water standards were met by the Point Woronzof discharge.
- H₀2: Water quality at the boundary of the ZID was not significantly changed with respect to nearfield or control stations.

1.4 CONTRACTOR

The MOA's designated contractor for the 1997/1998 Point Woronzof Monitoring Program was Kinnetic Laboratories, Inc. (KLI) of Anchorage, Alaska. Contract administrative and technical review were provided by CH2M Hill.

For influent, effluent, and sludge monitoring, priority pollutant analyses (gas chromatography/mass spectrometry scans), total petroleum hydrocarbons, and oil and grease analyses were conducted by Quanterra Incorporated (Anchorage, Alaska and West Sacramento, California). Trace metals (antimony, molybdenum, selenium, and thallium), aromatic hydrocarbon, and pesticide analyses were conducted by ToxScan, Inc. Asbestos analyses were performed by Solar Environmental Services, Inc. of Anchorage, Alaska.

In addition, the Municipality's Point Woronzof Laboratory performed monthly in-plant monitoring and analyses as part of its self-monitoring program and conducted trace metals analyses for the toxic pollutant and pesticide samplings.

Northern Testing Laboratories, Inc. (NTL) of Anchorage, under subcontract to KLI, provided analytical and field support for the receiving water quality sampling. Analytical support for the receiving water sampling was also provided by Battelle Northwest for trace metals (Sequim, Washington), and ToxScan, Inc. for aromatic hydrocarbons, total suspended solids, and cyanide (Watsonville, California). Supplemental polycyclic aromatic hydrocarbon and petroleum hydrocarbon analyses were conducted by the Geochemical and Environmental Research Group (GERG) of Texas A&M University (College Station, Texas).

1.5 PERIOD OF REPORT

The progress and results of the stipulated program during the thirteenth year of monitoring are covered in this report.

This report covers the period of 1 November 1997 through 31 October 1998.

2.0 METHODS

2.1 INFLUENT, EFFLUENT, AND SLUDGE MONITORING

2.1.1 Sampling

2.1.1.1 Toxic Pollutants and Pesticides

Toxic pollutants and pesticides are required by Permit to be sampled twice each year: once for Summer-dry and once for Summer-wet. The 1998 influent, effluent, and sludge sampling for toxic pollutants and pesticides was conducted on 18 - 19 June (Summer-dry) and 11 - 12 August (Summer-wet). All samples were collected by AWWU personnel. Influent was sampled at a representative location in the influent headworks, upstream from the recycle streams. Effluent was sampled at a well-mixed point downstream from the chlorination input (the final effluent line). Composite sludge samples were obtained from the belt filter press.

For both the Summer-dry and Summer-wet sampling events, samples were composited for the analysis of pesticides, semi-volatile organics, metals, asbestos, and cyanide. With the exception of cyanide, influent and effluent samples for these analyses consisted of composites of flow-proportioned samples collected over a 24-hr period. Influent and effluent cyanide samples consisted of three grabs taken eight hours apart, preserved immediately, and composited after flow weighting. Sludge composite samples, including those collected for the analysis of cyanide, consisted of 100 mL samples collected every hour over the 24-hr period. Grab samples for volatile organics analysis were collected every three hours during the 24-hr sampling period and designated for compositing during analysis at the laboratory. Grab samples were collected for analysis of total hydrocarbons as oil and grease, petroleum hydrocarbons, and purgeable aromatic compounds.

Samples were collected by AWWU personnel and shipped to the appropriate laboratories for analysis by KLI personnel. All samples were labeled with the sample date, sample identification number, and analysis to be performed. A chain of custody form listing all the samples and the names of the sampling personnel was included with each sample shipment for tracking purposes.

2.1.1.2 In-Plant Monitoring

In addition to the toxic pollutant and pesticide samplings, the effluent was sampled for fecal coliform, enterococci bacteria, hydrocarbons, and metals during the receiving water sampling, and the influent, effluent, and sludge were monitored under AWWU's self-monitoring program on a daily, weekly, and monthly basis (refer to Table 1). Single grabs were obtained for total residual chlorine, temperature, pH, dissolved oxygen (DO), and settleable solids for the required influent and effluent sampling. With the exception of cyanide and oil/grease, other influent and effluent samples were 24-hr composite samples obtained with a flow-proportional sampler. Cyanide and oil/grease were three grabs, taken eight hours apart, preserved immediately and composited after flow weighting. Sludge samples were three grabs (one per shift) taken eight hours apart.

2.1.2 Laboratory Analysis

The commercial laboratories were required to submit data reports listing analysis parameters by name, sample identification number, analysis method, concentration found, limit of detection, analyst, and quality assurance reviewer. Table 3 summarizes the preservation and analysis procedures for the influent, effluent, and sludge samples.

2.1.3 Data Analysis

The analytical results were tabulated by influent, effluent, and sludge to provide a check of mass constituent removal in the plant. These mass balance estimates can be used to determine the plant's performance. Effluent fecal coliform and enterococci bacteria data were evaluated along with the intertidal zone and stream bacterial sampling information.

2.2 WATER QUALITY MONITORING

2.2.1 Plume Dispersion Sampling

To sample along the discharge plume, drogues were deployed at both the outfall and control stations and then followed. Water quality stations were occupied along the drogue paths. Six drogue deployment and tracking cycles were performed at the Point Woronzof outfall: three were performed during the ebb tide, and three during the flood tide. An additional three drogue drops were performed at the control site near Point MacKenzie on a flood tide. A minimum of three water quality stations were occupied along each drogue path.

2.2.1.1 Field Methods

The plume location was followed by using a holey-sock drogue (Figure 4). The drogue consisted of a six-foot cylindrical nylon tube ballasted at the bottom with a five-pound weight and attached at the top with a bridle to a spherical float. This float attached to the tracking spar via a connecting line. The drogue used for the program changed in 1994 from the window-shade design to the cylindrical shape. Studies conducted by NOAA have indicated that current flow around a window-shade drogue may cause lift, similar to air flow for a sail boat (Flament, 1993, personal communication). Cylindrical or spherical designs that enclose a parcel of water have been found to more accurately follow the ambient current patterns. (Sombardier and Niiler, 1994).

Water quality stations were taken within the ZID, as near the ZID boundary as practical, and at a minimum of one nearfield location along the drogue path. Due to the extremely high currents (up to 5 knots), the drogue would cover the distance between the outfall and the ZID boundary in less than ten seconds. To perform the required sampling, the within-ZID station was taken prior to dropping the drogue.

The sampling was performed by positioning the survey vessel up current from the ZID and allowing the boat to drift down through the ZID. Sample depth was determined by using the survey vessel's fathometer. Niskin water bottles were placed on three separate hand lines and lowered to their appointed depths (surface, mid-depth, and bottom). While passing through the ZID, the water bottles were tripped with messengers, and a CTD (an *in situ* Conductivity, Temperature, and Depth sensor)

Table 3. Preservation and Analysis Procedures for Influent, Effluent, and Sludge.

Parameter	Preservation	Maximum Holding Time	Analysis ^a
Temperature (Inf/Eff only)	None required	Analyze immediately	SM 2550B
pH (Inf/Eff only)	None required	Analyze immediately	EPA 150.1
BOD ₅ (Inf/Eff only)	Cool, 4°C	48 hours	SM 5210B
Total Residual Chlorine (Eff only)	Fill completely dark storage	Analyze immediately	Hach DPD Colorimetric-DR100 (adopted from SM 4500-Cl G)
DO Electrode (Eff only)	None required	Analyze immediately	EPA 360.1
Settleable solids (Inf/Eff only)	Cool, 4°C	48 hours	SM 2540F
Suspended solids (Inf/Eff only)	Cool, 4°C	7 days	SM 2540D
Total solids (Sludge only)	Cool, 4°C	7 days	SM 2540B
Fecal Coliform Bacteria (Eff only)	Cool, 4°C 0.008% Na ₂ S ₂ O ₃	6 hours	MPN EPA 600/8-78-017
Oil and Grease (Inf/Eff only)	Cool, 4°C Hcl to pH<2	28 days	EPA 1664 HEM ^b SM 5520B ^d

**Table 3. Preservation and Analysis Procedures for Influent, Effluent, and Sludge.
(continued)**

Parameter	Preservation	Maximum Holding Time	Analysis^a
Cyanide (total)	Cool, 4°C, NaOH to pH>12, 0.6 g ascorbic acid (in presence of residual chlorine; Inf/Eff) Cool, 4°C	14 days	SM 4500-CN ⁻ C & E Hach C.14
Arsenic	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	EPA 206.2 SW 7060/3050A (digestion)
Beryllium	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	EPA 210.2 SW 7091/3050A (digestion)
Cadmium	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	SM 3111B SW 7130/3050A (digestion)
Chromium	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	SM 3111B SW 7190/3050A (digestion)
Copper	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	SM 3111B SW 7210/3050A (digestion)
Lead	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	EPA 239.2 SW 7421/3050A (digestion)
Mercury	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	28 days 14 days	EPA 245.1 SW 7470
Nickel	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	SM 3111B SW 7520/3050A (digestion)
Selenium	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	EPA 270.3 ^c SW 7741/3050A (digestion)
Silver	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	EPA 272.2 SW 7761/3050A (digestion)
Zinc	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	SM 3111B SW 7950/3050A (digestion)
Antimony	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	EPA 200.8 ^c SW 6020/3050A (digestion)
Molybdenum	Cool, 4°C, HNO ₃ to pH<2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	EPA 200.8 ^c SW 6020/3050A (digestion)
Thallium	Cool, 4°C, HNO ₃ to pH <2 (Inf/Eff) Cool, 4°C (Sludge)	6 months 28 days	EPA 200.8 ^c SW 6020/3050A (digestion)

Table 3. Preservation and Analysis Procedures for Influent, Effluent, and Sludge. (continued)

Parameter	Preservation	Maximum Holding Time	Analysis ^a
Total Petroleum Hydrocarbons (Inf/Eff only)	Cool, 4°C, dark HCl to pH <2	28 days	EPA 418.1(SM503E) ^b EPA 1664 SGT-HEM ^b
Total Hydrocarbons As Oil & Grease (Inf/Eff only)	Cool, 4°C, dark HCl to pH <2	28 days	EPA 413.2(SM503B) ^b EPA 1664 HEM ^b
Volatile Organics	Cool, 4°C, dark HCL to pH<2 Cool, 4°C (Sludge)	2 weeks	EPA 624, EPA 602 and xylenes (Inf/Eff) SW 8260 (Sludge)
Semi-Volatile Organics	Cool, 4°C, dark Cool, 4°C (Sludge)	7 days until extraction (14 days for Sludge) 40 days after extraction	EPA 625 (Inf/Eff) SW 8270 (Sludge)
Toxic Pollutants (40 CFR 401.15)	Cool, 4°C	7 days until extraction (Inf/Eff) 40 days after extraction (Sludge)	^e
Pesticides (40 CFR 125.58[M])	Cool, 4°C, pH 5-9 Cool, 4°C (Sludge)	7 days until extraction (Inf/Eff) 40 days after extraction (Sludge)	^e

^a Unless otherwise noted, "EPA" refers to the EPA document *Methods for Chemical Analysis of Water and Wastes*, revised March 1983, Document No. EPA-600/4-79-020; "SM" refers to *Standard Methods for the Examination of Water and Wastewater*, 18th ed., 1992. "SW" refers to the EPA Manual SW 846, *Test Methods for Evaluating Solid Waste*. 3rd Ed., 1986.

^b EPA, 1995. *Method 1664: N-Hexane Extractable Material (HEM) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM) by Extraction and Gravimetry (Oil and Grease and Total Petroleum Hydrocarbons)*. Document No. EPA-821-B-94-004.

^c Method used by Toxscan, Inc.

^d Method used by AWWU

^e Refer to 40 CFR Part 136 for approved preservation, holding, and analysis techniques

Inf Influent samples

Eff Effluent samples

Sludge Sludge samples

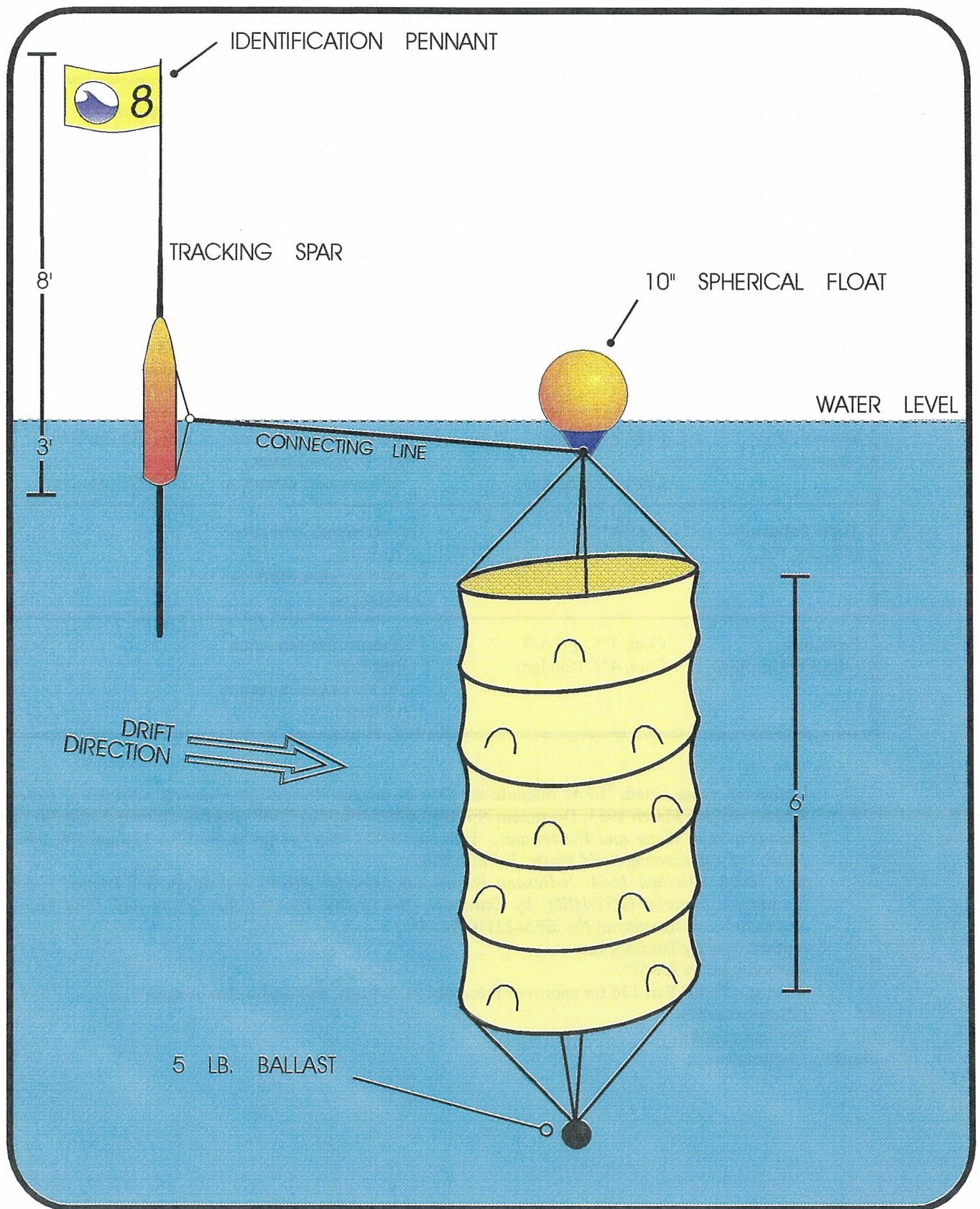


Figure 4. Holey-Sock Drogue, Flotation, and Marker Buoy.

was lowered to the bottom to obtain near-simultaneous measurements. Following completion of the within-ZID station, the survey vessel returned to the outfall and the drogue was dropped. The drogue was then followed, and water samples and CTD casts were obtained as the drogue passed the ZID boundary and upon reaching a nearfield location along the drogue path. At each water quality station, a microprocessor-controlled Seabird SEACAT SBE-19 CTD was used to obtain hydrographic profiles. Salinity and sigma-t were calculated from the conductivity, temperature, and depth. Dissolved oxygen and pH measurements were also obtained with the CTD.

Water quality samples were taken at the surface (0.5 m), mid-depth, and bottom to determine turbidity and dissolved oxygen. Color, total residual chlorine, fecal coliform bacteria, and enterococci bacteria samples were taken at the surface. To avoid any between-station contamination from the Niskin water sampler, bacteriological samples were taken by dipping the sample containers directly into the surface waters.

In addition to the Permit-required sampling described above, surface samples were obtained from the first three stations at the outfall flood and control flood sites. These samples were also collected by dipping the appropriate sample containers directly into the surface waters. Samples were analyzed for total aromatic hydrocarbons (EPA 602), dissolved and total recoverable metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc), total suspended solids (TSS), cyanide, and hydrocarbons as described below.

Analyses for polycyclic aromatic hydrocarbons (PAH), determined by mass spectrometry with selected ion monitoring (GC/MS SIM), and total hydrocarbons (aliphatics), determined by gas chromatography with flame ionization detection (GC/FID), were also performed on samples from these stations. In addition to the PAH and aliphatic determination, two pertinent sterols were determined in the GC/MS samples. Coprostanol and cholesterol have been observed in the effluent of sewage treatment plants from other areas and have been found to be useful indicators of pollution by sewage (Brown and Wade, 1984). Coprostanol is thought to be formed by stereo-specific bacterial reduction of cholesterol in humans and is one of the principal sterols found in feces (Brown and Wade, 1984). In addition, coprostanol is not a naturally-occurring sterol in aquatic systems. In addition, the unresolved complex mixture (UCM) component of the samples was also monitored through the GC/FID procedure. The UCM is defined as petroleum compounds that are represented by the total resolved plus unresolved area minus the total area of all peaks that have been integrated during the GC scan. This constituent is often indicative of weathered oils (National Research Council, 1985).

The vessel used for the survey was the F/V *CUTWATER*. In addition, a 14-ft Zodiac® was used to retrieve grounded drogues and conduct intertidal bacteria sampling. The Zodiac® was also used to transport samples ashore after each tidal cycle of drogue drops. This was necessary because of the short holding time for the dissolved oxygen and bacterial samples. Since chlorine samples must be processed immediately, samples were analyzed for total residual chlorine by amperometric titration onboard the survey vessel.

Navigation was accomplished with a Trimble Navigation differential global positioning system (GPS, Models 4000RL and 4000DL). Differential GPS is able to generate real-time positions with 2-5 m accuracy, equivalent to the Motorola MiniRanger III® (±3 m) system used previously. The advantages of this system are that only one reference station is required (not three), and positions

are output as latitude and longitude (in decimal seconds) and thus require minimal post-processing. The differential GPS system is essentially two separate GPS receivers (reference and differential) that communicate via UHF radio modem. The reference receiver is stationary and remains on a known benchmark, where it receives satellite signals and generates corrections based on the incoming signals versus the known location. The reference station continuously sends the corrections via radio signals to the differential receiver. The differential receiver is mobile and receives information from both the satellite and the reference station. The reference station chosen for the survey was adjacent to the western-most horizontal control point for the AWWU Point Woronzof facility (61°11'47.97" N, 150°01'13.56" W). In the event that differential GPS coordinates were erroneous or could not be obtained, the vessel was equipped with a standard GPS receiver and the distance and bearing to fixed landmarks on shore could be recorded from the vessel's radar and/or differential positions could be obtained during post-processing.

2.2.1.2 Laboratory Analysis

Laboratory analyses of samples followed the preservation and analysis procedures listed in Table 4. Turbidity and DO analyses were performed by KLI. Northern Testing Laboratories performed the analyses for color, total residual chlorine (TRC), fecal coliform bacteria, and enterococci bacteria. Battelle Northwest performed dissolved and total recoverable metals analyses. ToxScan, Inc. performed analyses for cyanide, TSS, and purgeable aromatic hydrocarbons. Additional hydrocarbon analyses (GC/MS SIM and GC/FID) were performed by the Geochemical and Environmental Research Group (GERG) of Texas A&M University.

2.2.1.3 Data Analysis

Laboratory data were tabulated by analytical parameters to allow comparison of stations. Additional information included date, tidal designation, current speed, and station location. The approximate current speed was determined from drogue position and time information.

Statistical analyses were performed to compare parameters at stations within the ZID, at the ZID boundary, beyond the ZID, and at the control site. For fecal coliform and TRC, stations were compared on the basis of control, within mixing zone (245 and 600 m around the diffuser for fecal and TRC, respectively), and the nearfield. Table 5 describes the station names and corresponding Ocean Data Evaluation System (ODES) designations.

All drogue data were plotted on plan view maps of the study area which show deployment and subsequent drogue positions as well as water quality station locations. Hydrographic profile data obtained with the CTD were plotted as vertical profiles for individual stations.

2.2.2 Intertidal Zone and Stream Bacterial Sampling

Bacterial sampling was performed at intertidal stations near Point Woronzof to determine the suitability of the shoreline water mass for appropriate water uses and the adequacy of the TRC effluent standard in protecting water quality. Bacterial samples were taken once during the water quality monitoring at the mouths of Ship, Chester, and Fish Creeks. Samples were analyzed for fecal coliform and enterococci bacteria. In addition, a sample was collected from Fish Creek for

Table 4. Preservation and Analysis Procedures for Water Quality.

Parameter	Preservation	Maximum Holding Time	Analysis ^a
Temperature	None	<i>in situ</i>	SM 2550 ^b
Salinity	None	<i>in situ</i>	SM 2520B ^b
pH	None	24 hours	SM 4500-H ⁺
Dissolved Metals	Filter then HNO ₃ to pH <2	6 months	Battelle ^c
Total Recoverable Metals	HNO ₃ to pH <2	6 months	Battelle ^c
Total Cyanide	NaOH, 4° C	14 days	EPA 335.3
Dissolved Oxygen (Winkler)	MnSO, alkali-iodide and H ₂ SO ₄	8 hours	SM 4500-O C
DO electrode (<i>in situ</i>)	None	<i>in situ</i>	SM 4500-O G
Turbidity	Cool, 4° C, dark	24 hours	SM 2130
Total Suspended Solids	Cool, 4° C	7 days	EPA 160.2
Fecal Coliform Bacteria	Cool, 4° C, dark	24 hours	SM 9221E
Enterococci Bacteria	Cool, 4° C, dark	24 hours	SM 9230B
Color	Cool, 4° C, dark	48 hours	SM 2120B
Total Residual Chlorine	None	Analyze immediately	SM 4500-Cl D/E
Total Aromatic Hydrocarbons	Cool, 4° C, dark, HCl, pH <2	14 days	EPA 602 and xylenes
Polycyclic Aromatic and Petroleum Hydrocarbons	Cool, 4° C, dark, HCl, pH <2	28 days	Battelle ^d

^a "SM" refers to *Standard Methods for the Examination of Water and Wastewater*, 18th ed., 1992. "EPA" refers to the EPA document *Methods for Chemical Analysis of Water and Wastes*, revised March 1983, Document No. EPA-600/4-79-020.

^b Modified for field instruments to make *in situ* measurements.

^c Dissolved metals were filtered before acidification; total recoverable metals were digested by ASTM Method D4309-91. Cadmium, lead, nickel, and silver were preconcentrated by methods described by Bloom and Crecelius (1984), *Anal. Chim. Acta* 156:139-145; then quantified by inductively coupled plasma/mass spectrometry (ICP/MS; EPA Method 200.8). Chromium and zinc were analyzed by direct injection GFAA (EPA Method 200.7). Mercury was analyzed by cold vapor atomic fluorescence, Bloom and Fitzgerald (1988), *Anal. Chim. Acta* 208:151-161.

^d Hydrocarbon methodology developed by Battelle; refer to the *Beaufort Sea Monitoring Program*, Boehm *et al.*, 1985, 1986, 1987, and 1988.

Table 5. ODES Station and Sample Labeling with Relation to ZID.

Station in Relation to ZID		ODES Code	
Within ZID		W	
ZID Boundary		B	
Beyond ZID (near-field)		N	
Reference (control)		R	

Station and sample labeling followed the format given in the example below:

Sample Number:	1	F	2	3	S	N
Field:	1	2	3	4	5	6

where:

FIELD 1	Visitation number; 1 = 1st survey
FIELD 2	F (flood), E (ebb), and C (control flood)
FIELD 3	Drogue number, 3 drogues per set
FIELD 4	Station number along particular drogue track
FIELD 5	S (surface), M (mid-depth), or B (near-bottom sample)
FIELD 6	Relation to ZID

NOTE: Fields 2, 3, and 4 designate the 3-digit station number which is required for ODES data entry.

supplemental hydrocarbon analyses (GC/MS SIM and GC/FID). An effluent sample was simultaneously obtained from the wastewater treatment facility and analyzed for fecal coliform and enterococci bacteria.

2.2.2.1 Field Methods

Nine intertidal bacteriological stations were occupied. Refer to Section 1.2.2.2 and Figure 3 for station locations. Stations were located by use of a MiniRanger during the first survey in 1986 and marked with survey stakes or flags and sightings from permanent landmarks. During some subsequent surveys, for stations that could not be located using markers, an Electronic Distance Measuring (EDM) device was used to verify distances along the beach prior to each survey.

Intertidal zone samples were taken from the 14-ft Zodiac® on a rising tide. Samples were collected directly into autoclaved specimen containers to avoid cross-contamination between stations. Two replicates were taken at each station. Stream samples were collected by wading into the stream and sampling directly into autoclaved specimen containers. Stream and intertidal zone sampling was performed during the flood tide and completed prior to high slack. Stream sampling was performed concurrently with the receiving water sampling.

2.2.2.2 Laboratory Analysis

Bacterial samples were analyzed by NTL which holds certification from the State of Alaska for these analyses. Sample labeling, handling, and laboratory tracking methods were the same as those described in the water quality section. Multiple tube Most Probable Number (MPN) techniques were used for both fecal coliform (SM 9221E) and enterococci bacteria (SM 9230B).

2.2.2.3 Data Analysis

Data for fecal coliform and enterococci were tabulated to indicate station, date, time, and tidal stage. Values were then compared with those found during the water quality monitoring.

2.3 BIOLOGICAL AND SEDIMENT MONITORING

During 1998, no biological or sediment monitoring was performed, as stipulated in the NPDES Permit.

3.0 RESULTS

3.1 INFLUENT, EFFLUENT, AND SLUDGE MONITORING

3.1.1 Toxic Pollutants and Pesticides Analyses

Toxic pollutant and pesticide monitoring for influent, effluent, and sludge was conducted on 18 - 19 June 1998 for Summer-dry weather and 11 - 12 August 1998 for Summer-wet weather. Sampling was performed over a 24-hour period by AWWU personnel.

Results of the toxic pollutant and pesticide analyses are given in Tables 6 (Summer-dry) and 7 (Summer-wet). Only those pollutants that were detected in the influent, effluent, or sludge are listed. Refer to Appendix B for a complete listing of toxic pollutants and pesticides analyzed. A number of the constituents were found only in the sludge. Pollutants found in the influent were often detected in the effluent, and vice versa. In general, pollutant concentrations were low. Many of the concentrations reported for the Summer-dry sampling in particular were below detection limits. Also, due to a laboratory error, Summer-dry volatile samples designated for compositing during analysis were analyzed individually. Values provided in Table 6 for this analysis are an average of values reported for the eight individual analyses, with zero used for non-detects.

Percent removal rates shown in these tables were computed from influent and effluent concentration values, with the reporting limit concentration used for pollutants reported as not detected (ND). Percent removal was not calculated when both influent and effluent concentrations were not detected (i.e., when compounds were only detected in sludge samples), or, for averaged values (EPA Method 624), if either the influent or effluent average value fell below the limit. Where several laboratory duplicate analyses were performed for a parameter, an average percent removal is provided.

Some of the pollutant removal rates were actually negative values due to the higher concentrations found in the effluent or where a compound was detected in the effluent but not the influent. Both positive and negative removals can be caused by effluent samples being more homogenous due to mixing in the clarifiers, whereas detecting a point-source pollutant in the influent is more haphazard.

Tables 6 and 7 include estimated influent and effluent concentrations of Tentatively Identified Compounds (TICs) for volatiles (EPA Method 624) and semi-volatiles (EPA Method 625). These compounds are included as required by the Permit, which calls for the identification of the ten most abundant constituents of each effluent extract indicated by peaks on the total ion plots, excluding priority pollutants and unsubstituted aliphatic compounds. As indicated in the Permit, reported concentrations of these compounds can be an order-of-magnitude estimate based upon comparison with an internal standard. This is considered a screening tool to indicate the presence of non-target compounds which are estimates because they are not included in the instrument calibration.

Total hydrocarbons as oil and grease were measured in the influent and effluent using two different methods: EPA 1664 HEM and SM 503B (SM5520C/EPA 413.2). The latter is a partition-infrared method for oil and grease that was required by the State of Alaska's Water Quality Standard Regulations 18 AAC 70 at the time of Permit issuance. In addition, total hydrocarbons in the influent and effluent were analyzed using SM 503E ((EPA 418.1) and EPA 1664 SGT-HEM). For further discussion of the significance of the total hydrocarbon values, refer to Section 5.1.

Table 6. Toxic Pollutants and Pesticides Detected in the Influent, Effluent, and Sludge, Sampled 18 - 19 June 1998 (Summer-dry).

Pollutant	Influent ^{a,b} ($\mu\text{g/L}$)	Effluent ^{a,b} ($\mu\text{g/L}$)	Sludge ^a ($\mu\text{g/g}$)	Percent Removal
VOLATILES (EPA Methods 624/8260)				
Benzene	0.18 ^{c,d}	ND(1.0)	ND(2.2) ^e	---
Chloroform	2.69 ^c	2.96 ^c	ND(2.2) ^e	-10
1,4-Dichlorobenzene	1.45 ^c	1.18 ^c	ND(2.2) ^e	19
Ethylbenzene	0.12 ^{c,d}	ND(1.0) ^c	ND(2.2) ^e	---
n-Propylbenzene	NT	NT	1.4 J ^e	---
Methylene Chloride	3.56 ^c	3.35 ^c	1.5 J ^e	6
Tetrachloroethene	1.82 ^c	1.50 ^c	ND(2.2) ^e	18
Toluene	9.18 ^c	8.60 ^c	3.0 ^e	6
1,2,4-Trimethylbenzene	NT	NT	11.0 ^e	---
1,3,5-Trimethylbenzene	NT	NT	3.4 ^e	---
m- & p-Xylenes	TIC	TIC	2.1 J ^e	---
Xylenes (Total)	NT	NT	ND(2.2)	---
VOLATILES (EPA Method 602)				
Benzene	0.74	0.70/0.70	NT	5/5
Ethylbenzene	ND(0.50)	0.51/0.51	NT	-2/-2
Toluene	8.1	6.4/6.3	NT	21/22
Xylenes	2.8	2.6/2.6	NT	7/7
1,2 Dichlorobenzene	0.79	1.3/1.4	NT	-65/-77
1,4 Dichlorobenzene	4.2	4.3/4.2	NT	-2/0
SEMI-VOLATILES (EPA Methods 625/8270)				
Benzo(a)anthracene	1.1 J	ND(9.9)	ND(26)	-800
Benzo(b)fluoranthene	1.7 J	1.3 J	ND(26)	24
Benzo(k)fluoranthene	1.7 J	1.5 J	ND(26)	12
Benzo(g,h,i)perylene	2.7 J	6.5 J	ND(26)	-141
Benzo(a)pyrene	1.8 J	1.7 J	ND(26)	6
Butyl benzyl phthalate	3.1 J	1.4 J	ND(26)	55
Chrysene	0.98 J	ND(9.9)	ND(26)	-910
Dibenz(a,h)anthracene	1.5 J	5.1 J	ND(26)	-240
1,4-Dichlorobenzene	1.1 J	ND(9.9)	ND(26)	-800
Diethyl phthalate	2.7 J	1.7 J	ND(26)	37
Di-n-butyl phthalate	2.1 J	1.3 J	ND(26)	38
3,3'-Dichlorobenzidine	2.8 J	ND(50)	ND(130)	-1,686
Di-n-octyl phthalate	2.9 J	1.7 J	ND(26)	41
bis(2-Ethylhexyl)phthalate	19 J ^f	9.6 J	34.0	49
Indeno(1,2,3-cd)pyrene	2.0 J	5.7 J	ND(26)	-185
Phenanthrene	1.4 J	ND(9.9)	ND(26)	-607
Phenol	37	ND(9.9)	3.8 J	73
4-Methylphenol	NT	NT	200.0	---

Table 6. Toxic Pollutants and Pesticides Detected in the Influent, Effluent, and Sludge, Sampled 18 - 19 June 1998 (Summer-dry). (continued)

Pollutant	Influent ^{a,b} (µg/L)	Effluent ^{a,b} (µg/L)	Sludge ^a (µg/g)	Percent Removal
HYDROCARBONS				
Oil & Grease (AWWU/NTL ^g ; EPA 1664-HEM)	82700	20200	NT	76
Oil & Grease (EPA 1664-HEM)	66000/ 40000	22000/ 26000/ 24000	NT	55
Total Hydrocarbons as Oil & Grease EPA 413.2 (SM503B)	56000	25000/25000	NT	55/55
Total Petroleum Hydrocarbons (EPA 1664-SGT-HEM)	ND(10000)/ ND(10000)	ND(10000)/ ND(10000)/ ND(10000)	NT	---
Total Petroleum Hydrocarbons EPA 418.1 (SM503E)	9900	4000/4100	NT	60/59
Total Aromatic Hydrocarbons as BETX from Method EPA 602	12.14	10.21/10.11	NT	16/17
METALS				
Antimony	ND(10)	ND(10)	3.9	---
Arsenic	4	3	7.4	25
Beryllium	ND(0.1)	ND(0.1)	0.06	---
Cadmium	ND(5)	ND(5)	3.5	---
Chromium	ND(5)	ND(5)	22	---
Copper	100	60	239	40
Lead	11	3	36	73
Mercury	0.6	0.1	1.5	83
Molybdenum	ND(10)	ND(10)	6.0	---
Nickel	10	10	18	0
Selenium	ND(0.30)	ND(0.30)	1.9	---
Silver	7.6	5.7	16.9	25
Thallium	ND(10)	ND(10)	ND(0.30)	---
Zinc	145	65	458	55
PESTICIDES (EPA Methods 608/8080, 614/8140)				
4,4'-DDT	ND(0.020)	ND(0.020)/ ND(0.020)	0.011	---
OTHER COMPONENTS				
Asbestos ^h	ND(24.3)	ND(48.6)	ND	---
Cyanide	ND(20)	ND(20)	ND(3.13)	---

Table 6. Toxic Pollutants and Pesticides Detected in the Influent, Effluent, and Sludge, Sampled 18 - 19 June 1998 (Summer-dry). (continued)

Pollutant	Influent ^{a,b} (μg/L)	Effluent ^{a,b} (μg/L)	Sludge ^a (μg/g)	Percent Removal
VOLATILES - TENTATIVELY IDENTIFIED COMPOUNDS (EPA Methods 624/8260)ⁱ				
Acetone	3.1 ^c	7.3 ^c	NT	---
Undecane	5.5 ^c	5.1 ^c	NT	---
1-Limonene	19.8 ^c	3.6 ^c	NT	---
Decane	3.8 ^c	3.3 ^c	NT	---
p-Xylene	0.4 ^c	2.5 ^c	NT	---
p-Isopropyltoluene (p-Cymene)	1.2 ^c	2.3 ^c	NT	---
Benzene, 1-ethyl -2-methyl-	0.7 ^c	2.0 ^c	NT	---
Benzene, 1,2,4-trimethyl-	0.4 ^c	1.5 ^c	NT	---
Benzene, 1,2,4,5-tetramethyl-	1.7 ^c	1.4 ^c	NT	---
Benzene, 1-methyl-3-propyl	0.8 ^c	1.4 ^c	NT	---
SEMI-VOLATILES - TENTATIVELY IDENTIFIED COMPOUNDS (EPA Methods 625/8270)ⁱ				
Hexanoic acid	ND	140	NT	---
Caffeine	ND	76	NT	---
Unknown n-substituted aliphatic hydrocarbon	ND	62	NT	---
Pentanoic acid	56	58	NT	---
Butanoic acid, 3-methyl-	55	55	NT	---
Unknown alkene #01	67	55	NT	---
5-Eicosene, (E)-	ND	51	NT	---
Butanoic acid, 2-methyl-	ND	50	NT	---
Benzeneacetic acid	ND	46	NT	---
Octadecanoic acid	ND	44	NT	---

- ^a Detection limits are included in parentheses for non-detected (ND) values
^b Duplicate field sample analysis or duplicate laboratory analysis provided (value/duplicate value)
^c Values presented are an average of all eight samples collected with zero used for non-detects
^d Average is below the detection limit
^e Sludge EPA 8260 samples analyzed outside of holding time
^f Value above detection limit but estimated due to matrix interference
^g AWWU oil and grease analyses (typically performed by SM 5520B) contracted to NTL during this time period
^h Asbestos reported in million fibers/L (influent or effluent) or present or not detected (sludge)
ⁱ Tentatively identified compounds are based on the 10 most abundant constituents found in the effluent
--- Not applicable (not calculated)
J Result is detected below the reporting limit or is an estimated concentration
ND None detected
NT Not tested
TIC Tentatively identified compounds based on the 10 most abundant constituents found in the effluent

Table 7. Toxic Pollutants and Pesticides Detected in the Influent, Effluent, and Sludge, Sampled 11 - 12 August 1998 (Summer-wet).

Pollutant	Influent ^{a,b} (µg/L)	Effluent ^{a,b} (µg/L)	Sludge ^a (µg/g)	Percent Removal
VOLATILES (EPA Methods 624/8260)				
Benzene	ND(1.0)	ND(1.0)	ND(0.81)	---
Chloroform	3.0	3.3	ND (0.81)	-10
Ethylbenzene	1.5	ND (1.0)	ND (0.81)	33
Methylene Chloride	6.3	7.2	ND (0.81)	-14
Tetrachloroethene	6.6	3.2	ND (0.81)	52
Toluene	12	9.5	ND (0.81)	21
Xylenes (Total)	NT	NT	ND(0.81)	---
VOLATILES (EPA Method 602)				
Benzene	1.8	1.3/1.3	NT	28/28
Toluene	17	8.0/8.0	NT	53/53
Ethylbenzene	0.8	1.5/1.5	NT	-88/-88
1,2 Dichlorobenzene	3.1	1.9/0.72	NT	39/77
1,4 Dichlorobenzene	3.1	8.8/9.9	NT	-184/-219
Xylenes	4.4	9.8/9.9	NT	-123/-125
SEMI-VOLATILES (EPA Methods 625/8270)				
bis(2-Ethylhexyl)phthalate	18	15	180	17
Phenol	18	12	ND (100)	33
4-Methylphenol	NT	NT	1000	---
HYDROCARBONS				
Oil & Grease (AWWU/NTL ^c ; EPA 1664-HEM)	159000	24400	NT	85
Oil & Grease (EPA 1664-HEM)	110000/ 110000	32000/ 24000/ 21000	NT	77
Total Hydrocarbons as Oil & Grease EPA 413.2 (SM503B)	180000	30000	NT	83
Total Petroleum Hydrocarbons (EPA 1664-SGT- HEM)	ND(10000)/ ND(10000)	ND(10000)/ ND(10000)/ ND(10000)	NT	---
Total Petroleum Hydrocarbons EPA 418.1 (SM503E)	3900/6400	2600/2600/2600	NT	50
Total Aromatic Hydrocarbons as BTEX from EPA Method 602	24	20.6/20.7	NT	14/14

Table 7. Toxic Pollutants and Pesticides Detected in the Influent, Effluent, and Sludge, Sampled 11 - 12 August 1998 (Summer-wet). (continued)

Pollutant	Influent ^{a,b} ($\mu\text{g/L}$)	Effluent ^{a,b} ($\mu\text{g/L}$)	Sludge ^a ($\mu\text{g/g}$)	Percent Removal
METALS				
Antimony	ND(10)	ND(10)/ND(10)	3.6	---
Arsenic	34	13	18.7	62
Beryllium	ND(0.1)	ND(0.1)	0.07	---
Cadmium	ND(10)	ND(10)	3.7	---
Chromium	ND(5)	ND(5)	22	---
Copper	92	49	258	47
Lead	13	8	85	38
Mercury	0.35 ^d	ND(0.2) ^d	3.43 ^d	43
Molybdenum	ND(10)	ND(10)/ND(10)	5.4	---
Nickel	30	40	21	-33
Selenium	ND(10)	ND(10)/ND(10)	ND(0.30)	---
Silver	13.8	11.3	14.5	18
Thallium	ND(10)	ND(10)/ND(10)	ND(0.30)	---
Zinc	187	79	562	58
PESTICIDES (EPA 608/8080, 614/8140)				
NONE DETECTED				
OTHER COMPONENTS				
Asbestos ^c	ND(2.98)	ND(2.98)	ND	---
Cyanide	ND (20)	ND (20)	ND (2.53)	---

Table 7. Toxic Pollutants and Pesticides Detected in the Influent, Effluent, and Sludge, Sampled 11 - 12 August 1998 (Summer-wet). (continued)

Pollutant	Influent ^{a,b} (µg/L)	Effluent ^{a,b} (µg/L)	Sludge ^a (µg/g)	Percent Removal
VOLATILES - TENTATIVELY IDENTIFIED COMPOUNDS (EPA Methods 624/ 8260)^f				
Acetone	ND	2.5	NT	---
Benzene, 1-ethyl-2-methyl	ND	5.3	NT	---
Benzene, 1-ethyl-4-methyl	ND	5.9	NT	---
Benzene, 1,2,3-trimethyl-	5.9	3.5	NT	---
Benzene, 2-propenyl	ND	5.9	NT	---
n-Propylbenzene	ND	3.0	NT	---
m-Xylene	ND	5.2	NT	---
l-Limonene	21	10	NT	---
1,2,4-Trimethylbenzene	ND	9.5	NT	---
Undecane	11	6.5	NT	---
SEMI-VOLATILES - TENTATIVELY IDENTIFIED COMPOUNDS (EPA METHODS 625/ 8270)^f				
Oxacyclotetradecane-2,11-dione, 13-methyl-	ND	240	NT	---
Unknown oxygenated compound #01	ND	220	NT	---
Unknown carboxylic acid #01	28	100	NT	---
Unknown cyclic alkane #01	610	71	NT	---
Unknown substituted PAH #01	ND	62	NT	---
Pentanoic acid	ND	57	NT	---
Unknown #01	ND	56	NT	---
Butanoic acid	ND	55	NT	---
Ethanol, 2-(2-butoxyethoxy)-	ND	54	NT	---
Tetradecanoic acid	ND	47	NT	---

- ^a Detection limits are included in parentheses for non-detected (ND) values
^b Duplicate field sample analysis or duplicate laboratory analysis provided (value/duplicate value)
^c AWWU oil and grease analyses (typically performed by SM 5520B) contracted to NTL during this time period
^d Holding time exceeded for mercury samples
^e Asbestos reported in million fibers/L (influent or effluent) or present or not detected (sludge)
^f Tentatively identified compounds are based on the 10 most abundant constituents found in the effluent
--- Not applicable
ND None detected
NT Not tested

Metals concentrations were generally found to be low. Effluent concentrations of antimony, beryllium, cadmium, chromium, molybdenum, selenium, and thallium were below detection limits during both sampling periods. The effluent copper concentration was the highest of any of the metals with respect to its Maximum Allowable Effluent Concentration (MAEC). The MAEC is the value specified in the NPDES Permit as the receiving water limit times the initial dilution of 25:1 of the outfall. During the Summer-dry sampling, the concentration of copper in the effluent was 60 $\mu\text{g/L}$, compared to an MAEC of 100 $\mu\text{g/L}$. The Summer-wet sampling showed an effluent copper concentration of 49 $\mu\text{g/L}$. The mercury concentration in the effluent was 0.1 $\mu\text{g/L}$ for the Summer-dry sampling and non-detected with a detection limit of 0.2 $\mu\text{g/L}$ for the Summer-wet sampling as compared to the 0.625 MAEC. Holding times were exceeded for the Summer-wet mercury samples.

The concentrations of cyanide in influent and effluent were less than the detection limit of 20 $\mu\text{g/L}$ during both the Summer-dry and Summer-wet samplings as compared to an MAEC of 50 $\mu\text{g/L}$.

The types and concentrations of measured organic compounds varied considerably between the two sampling periods. Methylene chloride, a common laboratory reagent, was detected in most of the water matrix (influent/effluent) samples, but was not detected in the laboratory method blanks. Other compounds that were frequently detected in the influent and effluent samples included 1, 2- and 1,4-dichlorobenzene, benzene, chloroform, tetrachloroethene, and toluene. None of these compounds were detected in the laboratory method blanks.

No pesticides were detected in the influent or effluent during the Summer-dry or Summer-wet sampling periods. The pesticide 4,4'-DDT was detected in the sludge sample during the Summer-dry sampling event, while no pesticides were detected in the sludge during the Summer-wet sampling. For a complete list of the various pesticide analytes, refer to Appendix B, Section 2.0. Asbestos was not detected in influent, effluent, or sludge samples for either period.

3.1.2 Monthly Discharge Monitoring Data

Results of AWWU's daily, weekly, and monthly sampling in the wastewater treatment plant influent and effluent are presented as monthly summaries in Tables 8 and 9, and sludge monitoring results are presented in Table 10. Averages and percent removal rates are based on the 12-month period from November 1997 through October 1998.

Arsenic values for influent, effluent, and sludge were slightly higher than last year. The average arsenic concentrations for influent and effluent were 4 and 3 $\mu\text{g/L}$, respectively. The average arsenic value for sludge appears to be substantially higher than last year at 18.1 mg/kg dry weight, but this high average was the result of an extremely elevated arsenic concentration (257 mg/kg) reported for one sampling during July 1998. An additional arsenic analysis performed during July 1998 due to this high value showed a more typical value of 14.5 mg/kg. High values of arsenic and other metals in the sludge at this time were ascribed to high influent concentrations of these components coming in to the plant. Refer to Section 5.1 for a discussion of these values with respect to previous samplings.

Metals values in the influent and effluent were generally low. Effluent metal concentrations were always below their MAEC's using a 25:1 dilution computation applied to the receiving water standards (refer to Section 5.1).

Table 8. Discharge Monitoring Data for Influent and Effluent Heavy Metals, Arsenic, and Cyanide.^a
Concentrations are in $\mu\text{g/L}$.

Month	Flow Rate (MGD)	Arsenic		Beryllium		Cadmium		Copper		Lead	
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
11/97	29.5	3	2	0.1	0.1	<5	<5	65	47	10	6
12/97	28.4	4	<2	<0.1	<0.1	6	6	65	38	4	<1
01/98	28.7	3	2	<0.1	<0.1	<5	<5	76	41	21	5
02/98	28.2	3	2	<0.1	<0.1	<5	<5	73	49	8	4
03/98	30.0	2	2	<0.1	<0.1	<5	<5	65	31	15	21
04/98	30.7	3	<2	<0.1	<0.1	5	6	80	30	14	6
05/98	28.6	<2	2	<0.1	<0.1	<5	<5	60	30	11	<1
06/98	28.7	3	2	<0.1	<0.1	6	5	80	40	11	4
07/98	26.6	13 ^b	15 ^b	<0.1	<0.1	<5 ^b	<5 ^b	90 ^b	60 ^b	26 ^b	11 ^b
08/98	28.9	6	3	<0.1	<0.1	1.3	0.5	63	41	5	3
09/98	27.5	5	3	<0.1	<0.1	<5	<5	80	40	10	7
10/98	27.7	5	<2	<0.1	<0.1	<5	<5	90	40	10	4
Average	28.6	4	3	0.1	0.1	5	5	74	41	12	6
Percent Removal		25		0		0		45		50	

Table 8. Discharge Monitoring Data for Influent and Effluent Heavy Metals, Arsenic, and Cyanide.^a (continued)
 Concentrations are in $\mu\text{g/L}$.

Month	Flow Rate (MGD)	Mercury		Nickel		Silver		Zinc		Chromium		Cyanide	
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
11/97	29.5	<0.2	<0.2	<20	<20	7.2	5.0	106	53	<5	<5	<10	20
12/97	28.4	<0.2	<0.2	20	20	12.6	7.9	127	60	<5	12	<10	20
01/98	28.7	0.5	<0.2	<20	20	12.7	7.1	131	63	<5	<5	<10	10
02/98	28.2	0.4	<0.2	<20	<20	16.1	9.8	114	66	6	13	<10	10
03/98	30.0	0.3	<0.2	<20	<20	13.6	8.2	125	62	9	16	<10	10
04/98	30.7	0.4	<0.1	<20	<20	10.8	6.1	144	54	10	10	<10	10
05/98	28.6	0.1	0.1	<20	<20	4.4	3.7	104	57	<10	<10	<20	<20
06/98	28.7	0.3	0.1	<20	<20	14.2	7.1	145	66	10	10	<40	<20
07/98	26.6	0.4	0.1	<20 ^b	<20 ^b	16.0	11.1	132 ^b	64 ^b	<10 ^b	<10 ^b	<20	<20
08/98	28.9	0.2	<0.2	77	20	4.6	3.0	137	88	6	8	<20	<20
09/98	27.5	0.5	<0.1	40	40	13.6	7.4	181	66	<10	<10	<10	10
10/98	27.7	0.2	0.1	<20	<20	6.9	4.6	182	63	<10	10	<10	<10
Average	28.6	0.3	0.2	26	22	11.1	6.8	136	64	8	10	15	15
Percent Removal		33		15		39		53		-25		0	

^a All metals are reported as total metals

^b Results are an average of two sampling events this month

Table 9. Discharge Monitoring Data for Influent and Effluent Non-Metals.

Month	Temperature Average (°C)		pH Minimum/Maximum (pH)		Cl ₂ Total Residual Average (mg/L)		D.O. Average (mg/L)		BOD ₅ Average (mg/L)		Settleable Solids Average (mL/L)		Total Susp. Solids Average (mg/L)		Fecal Coliform Average (FC/100 mL)		Oil and Grease Average (mg/L)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
11/97	12.5	12.7	7.0/7.7	6.8/7.5	NA	0.8	NA	6.2	238	112	6.4	<0.1	238	46	NA	26	NA	24.2
12/97	11.8	11.9	7.0/7.8	6.9/7.7	NA	0.8	NA	6.4	229	108	6.5	<0.1	234	44	NA	16	NA	28.1
01/98	11.0	11.4	6.9/7.7	6.9/7.6	NA	0.8	NA	6.6	218	106	6.0	<0.1	204	44	NA	14	NA	24.6
02/98	11.0	11.4	7.2/7.9	7.0/7.7	NA	0.8	NA	6.7	246	112	6.0	<0.1	222	53	NA	22	NA	25.4
03/98	10.3	10.9	6.8/7.8	6.5/7.9	NA	0.8	NA	6.5	232	104	6.6	<0.1	239	55	NA	34	NA	25.8
04/98	10.6	11.0	6.4/7.6	6.7/7.4	NA	0.9	NA	6.4	206	93	6.3	<0.1	238	54	NA	12	NA	23.7
05/98	11.1	11.6	6.6/7.5	6.6/7.3	NA	0.8	NA	6.5	184	91	7.6	<0.1	242	55	NA	16	NA	13.5 ^a
06/98	12.4	13.3	6.8/7.5	6.8/7.5	NA	0.8	NA	6.1	230	102	6.3	<0.1	254	51	NA	12	NA	26.6 ^a
07/98	13.8	14.6	6.5/7.5	6.8/7.3	NA	0.8	NA	5.9	272	117	6.1	<0.1	292	46	NA	33	NA	24.9 ^a
08/98	14.7	15.1	6.9/7.7	6.8/7.5	NA	0.9	NA	5.9	272	113	5.8	<0.1	285	48	NA	32	NA	25.4
09/98	14.2	14.8	7.0/7.6	6.9/7.4	NA	0.9	NA	6.0	253	111	6.4	<0.1	280	50	NA	44	NA	23.4
10/98	13.8	14.2	7.2/7.7	6.9/7.2	NA	0.8	NA	5.6	258	121	7.2	<0.1	279	50	NA	13	NA	24.1
Average	12.3	12.7	6.4/7.9 ^b	6.5/7.9 ^b	---	0.8	---	6.2	236	108	6.4	<0.1	251	50	---	23	---	24.1
Percent Removal	---		---		---		---		54		98		80		---		---	

^a EPA Method 1664-HEM used for oil and grease determination^b Yearly (minimum-maximum)

NA Not analyzed

---- Not applicable

Table 10. Discharge Monitoring Data for Sludge Heavy Metals, Arsenic, and Cyanide^a. Concentrations are in mg/kg dry weight.

Month	Flow Rate (MGD)	Arsenic	Beryllium	Cadmium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Chromium	Cyanide
11/97	29.5	5.5	0.13	4.6	266	61	2.1	26	28.4	588	22	1.50
12/97	28.4	4.3	0.10	1.9	194	44	0.7	15	20.8	417	12	0.71
01/98	28.7	5.3	0.14	1.6	197	47	1.0	19	25.2	396	55	0.58
02/98	28.2	7.4	0.09	4.1	228	50	1.2	15	14.1	429	18	0.86
03/98	30.0	4.4	0.13	3.2	218	40	2.1	22	28.5	446	22	2.00
04/98	30.7	4.1	0.11	3.2	197	43	2.6	18	21.5	392	17	1.14
05/98	28.6	3.6	0.08	2.5	176	33	0.7	13	24.3	405	13	<3.0
06/98	28.7	5.1	0.07	2.9	225	51	1.0	21	24.4	513	16	<3.0
07/98	26.6	135.8 ^b	0.08	5.2 ^b	276 ^b	294 ^b	2.9	16 ^b	80.5	571 ^b	22 ^b	<2.49
08/98	28.9	20.8	0.11	0.7	227	58	1.4	11	14.5	432	5	<2.63
09/98	27.5	5.9	0.08	3.2	270	47	1.2	23	27.7	576	17	2.03
10/98	27.7	14.4	0.09	3.4	269	70	1.1	21	7.2	655	20	0.87
Average	28.6	18.0	0.10	3.0	229	70	1.5	18	26.4	485	20	1.73

^a

All metals are reported as total metals

^b

Results are an average of two sampling events this month

Removal of BOD₅ averaged 54%, and removal of suspended solids averaged 80% for the 12-month reporting period. These averages far exceed the minimums required by the amendments to the Clean Water Act (40 CFR Part 125.60; Final Rule, 8/9/94), whereby dischargers with 301(h) waivers are required to remove 30% of BOD₅ and 30% of the suspended solids.

3.2 WATER QUALITY MONITORING RESULTS

Water quality sampling of the receiving water was conducted from 11 - 12 August 1998. Sampling results are contained in the following subsections.

3.2.1 Plume Dispersion Sampling

3.2.1.1 Drogue Tracking Results

Drogues were released on 11 August 1998 at the ZID station for the ebb and flood tidal cycles and 12 August 1998 at the control station for the flood tidal cycle. Three drogues were deployed during each tidal cycle.

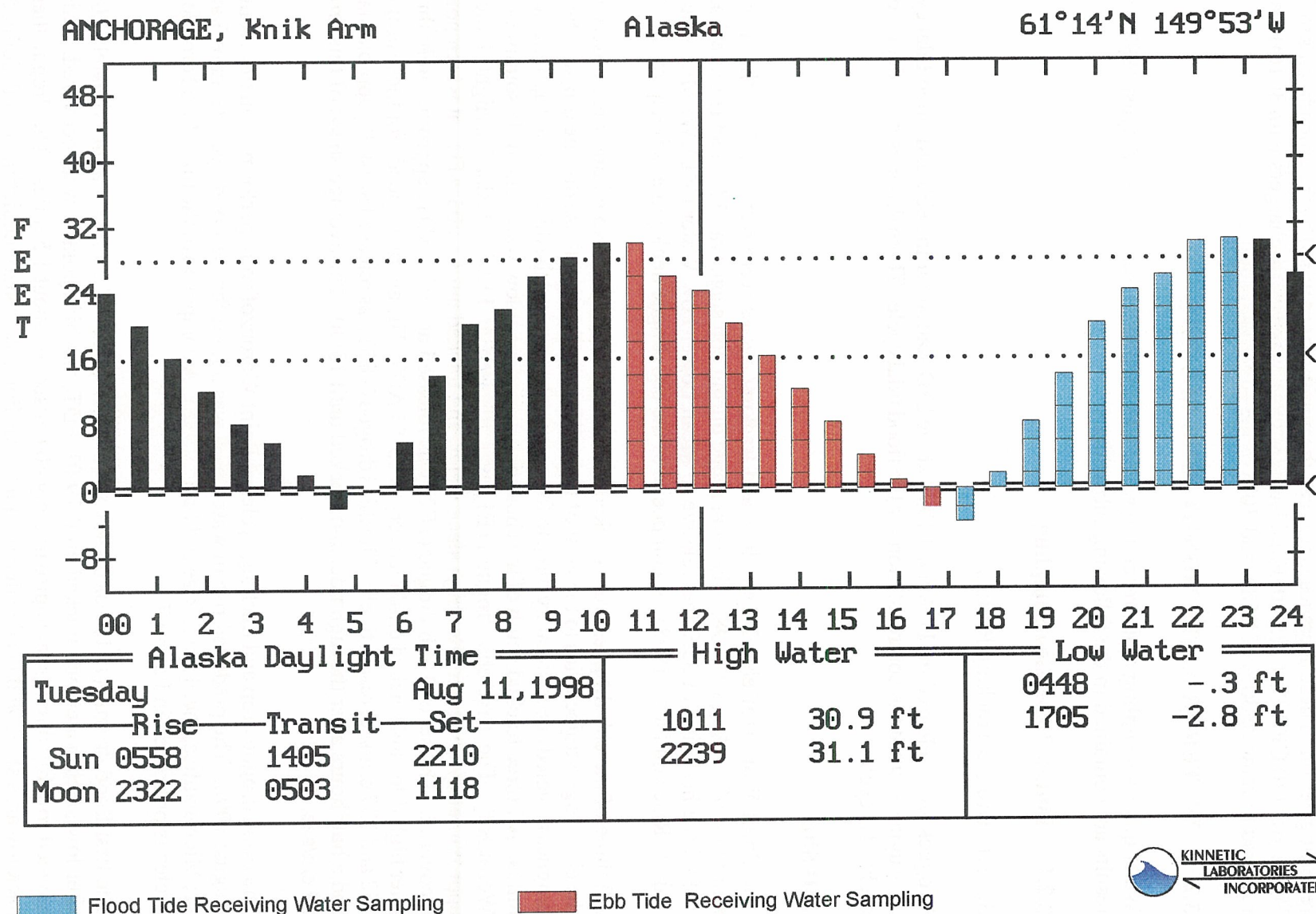
ZID Site

The Point Woronzof ebb drogue drop and tracking cycles were performed on the morning and afternoon of 11 August 1998. The tidal range during ebb stage was 33.7 feet (Figure 5 and Table 11) with a high tide of 33.9 feet relative to Mean Lower Low Water (MLLW; Micronautics, Inc. Tide 1: Rise and Fall®, 1998). A composite of the ebb drogue deployments is depicted in Figure 6.

All three of the ebb drogues were tracked toward the southwest. No eddies were observed during the ebb drogue trajectories to the west of Point Woronzof during these drogue drops. The first two drogues traveled approximately three to four nautical miles, and the third traveled approximately two miles. All three tracked south of the shoal that is evident at low water one mile southwest of Point Woronzof. The first ebb drogue (1E1) was released at 11:08 Alaska Daylight Time (ADT), approximately one hour after high slack water, and tracked until 12:03 ADT, at which point it was recovered. The second ebb drogue (1E2) was released at 13:05 ADT, approximately three hours after high tide, and tracked until recovery at 13:55 ADT. The average speeds for these drogues were 142 and 137 cm/sec, respectively. The third drogue (1E3) was released at 14:33, approximately four and a half hours after the high tide, and tracked until 15:30. The average speed of this drogue was 69 cm/sec.

The flood drogue drop and tracking cycles at Point Woronzof were performed on the evening of 11 August 1998. The predicted rise in water level was 33.9 ft for the flood cycle (Figure 5 and Table 11; Micronautics, Inc. Tide 1: Rise and Fall®, 1998). A composite of the three flood drogue tracking cycles is presented in Figure 7.

The first flood drogue (1F1) was deployed on 11 August at 17:25 ADT, approximately 20 minutes after low slack water, and tracked until 19:01 ADT, at which point it was recovered. This drogue traveled roughly due east at approximately 40 cm/sec for about 1.5 miles. The drogue then looped back towards shore and headed due west towards Point Woronzof depicting a well-defined lee side eddy to the east of the point.



Output from TIDE1 RISE AND FALL, Micronautics, Inc. (C) 1998

Figure 5. Tidal Information For Receiving Water Sampling, Flood and Ebb Tides.

Table 11. 1998 Drogue Tracking Information.

Date	Station	Tidal Information				Drogue No.	Release Time After Slack (Hours:Minutes)	Drogue Speed (cm/s)
		Slack Water (Alaska Daylight Time ^a ; Stage)		Direction	Range (Feet) ^b			
11 Aug 1998	ZID	10:11	HIGH	EBB	33.7	1E1	00:58	142
11 Aug 1998	ZID	10:11	HIGH	EBB	33.7	1E2	02:54	137
11 Aug 1998	ZID	10:11	HIGH	EBB	33.7	1E3	04:22	69
11 Aug 1998	ZID	17:05	LOW	FLOOD	33.9	1F1	00:20	40
11 Aug 1998	ZID	17:05	LOW	FLOOD	33.9	1F2	02:19	158
11 Aug 1998	ZID	17:05	LOW	FLOOD	33.9	1F3	03:53	141
12 Aug 1998	CONTROL	17:46	LOW	FLOOD	32.9	1C1	-00:05	52
12 Aug 1998	CONTROL	17:46	LOW	FLOOD	32.9	1C2	02:02	180
12 Aug 1998	CONTROL	17:46	LOW	FLOOD	32.9	1C3	03:45	147

^a Tide1: Rise and Fall®, Micronautics, Inc. 1998. (Knik Arm, Anchorage)

^b Predicted water level variations during tide.

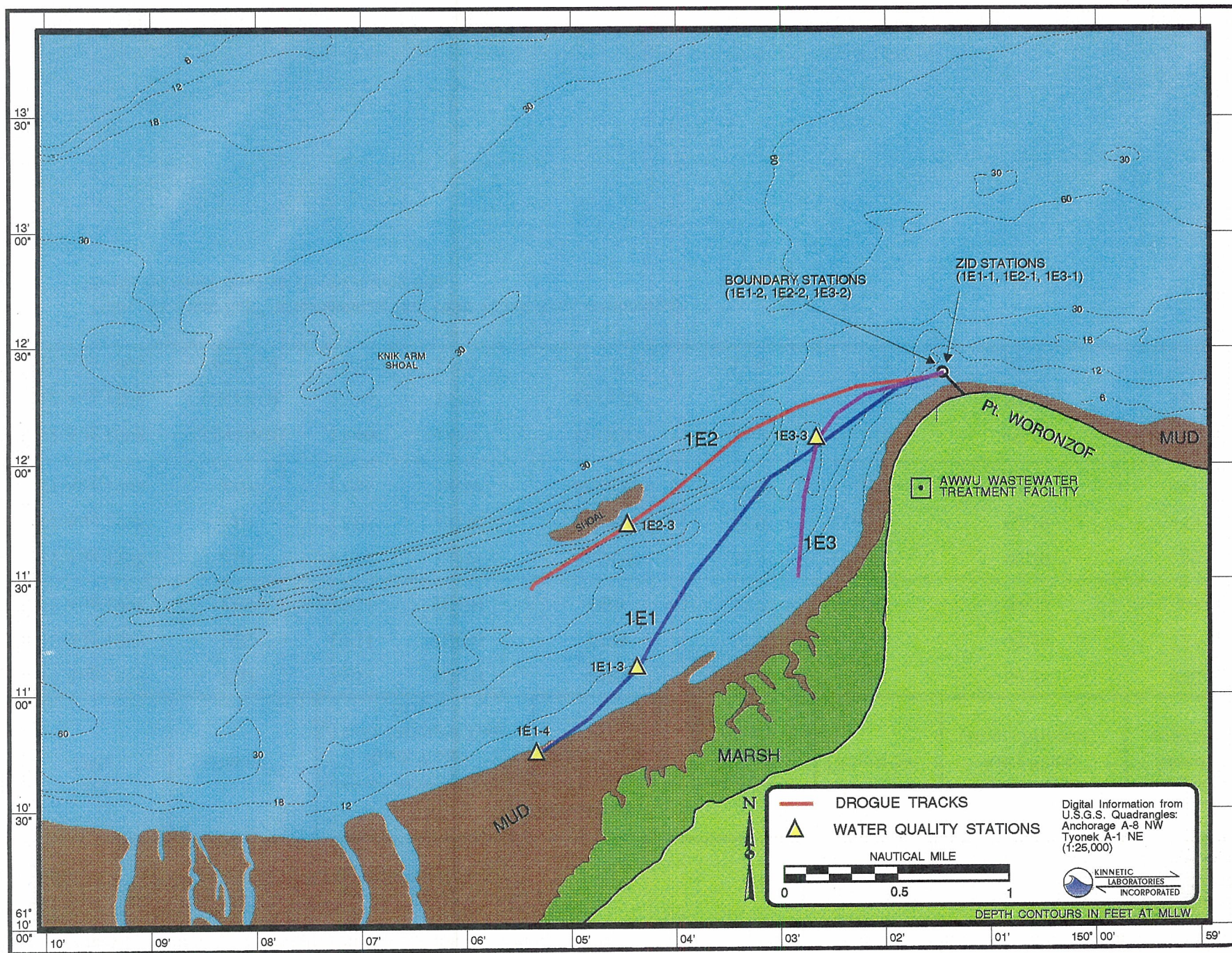


Figure 6. Summary of Ebb Drogue Tracks and Receiving Water Sampling Locations at Point Woronzof, 11 August 1998.

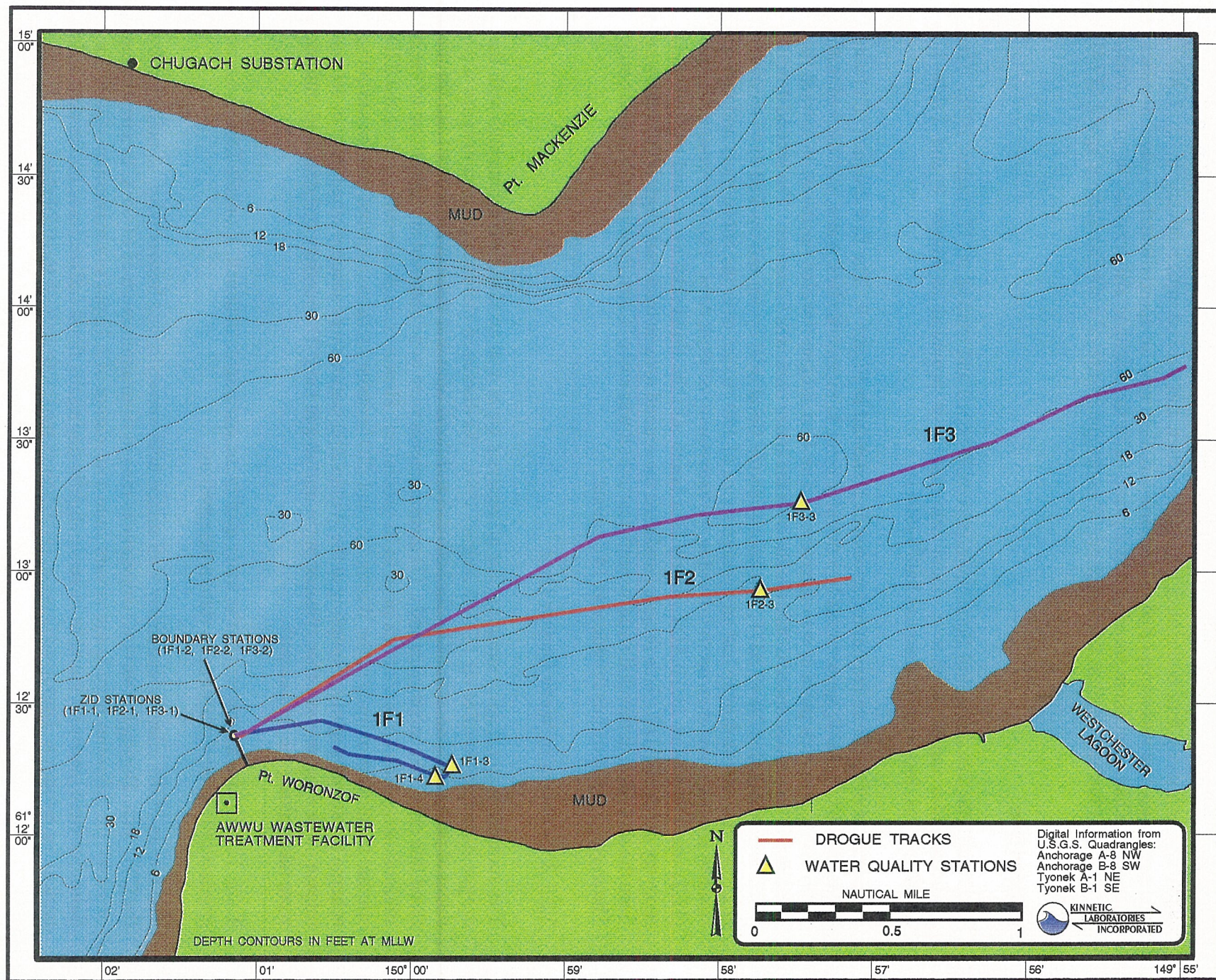


Figure 7. Summary of Flood Drogue Tracks and Receiving Water Sampling Locations at Point Woronzof, 11 August 1998.

The second flood drogue (1F2) was deployed at 19:24 ADT, nearly two hours after low slack, and tracked until it was recovered at 20:08 ADT. The third flood drogue (1F3) was deployed at 20:58 ADT, approximately four hours after high slack water, and tracked until recovery at 22:17 ADT. The second drogue was transported to the northeast, then east for approximately 4 nautical miles. This drogue had an average speed of 158 cm/sec. The third drogue also traveled in an northeast direction but further out from the shoreline. This drogue exhibited a similar average speed of 141 cm/sec.

Control Site

The Point MacKenzie control flood drogues were dropped and tracked on 12 August 1998. The predicted tidal range of 32.9 ft. Tidal information is provided in Figure 8 and Table 11 (Micronautics, Inc. Tide 1: Rise and Fall®, 1998).

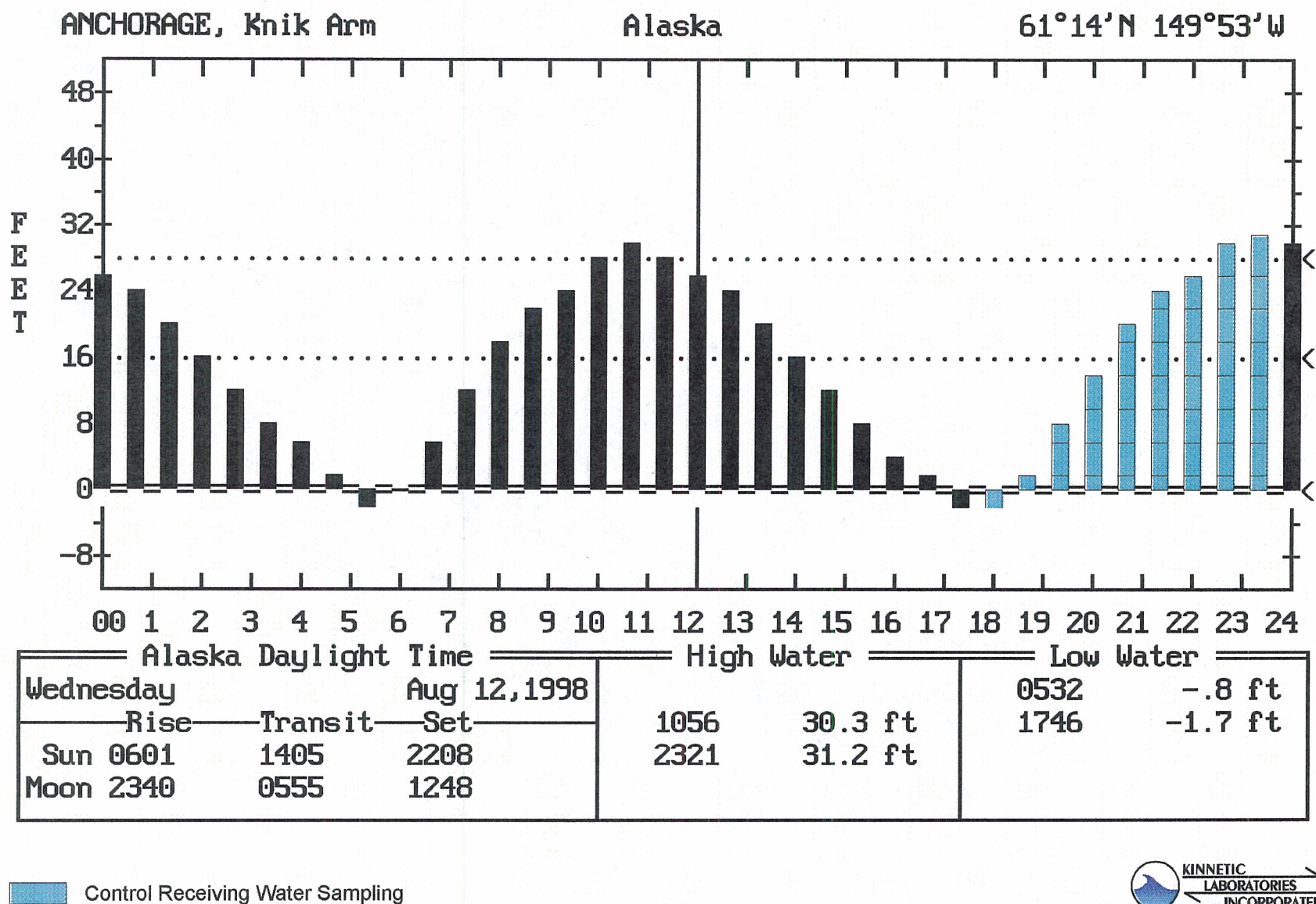
A composite of the three drogue trajectories is presented in Figure 9. The first drogue (1C1) was released at 17:41 ADT, approximately 5 minutes prior to estimated slack water, and tracked until 19:26 ADT, at which point it was recovered. The first drogue traveled northeast in toward the shoreline. The average speed of this drogue over the entire track was 52 cm/sec. The second drogue (1C2) was released at 19:48 ADT, two hours into the flood tidal cycle, and tracked until recovery at 21:00 ADT. This drogue had an average speed of 180 cm/sec over the entire track and moved steadily northeast and then north following the bathymetry of Knik Arm. The third control drogue (1C3) was released at 21:31 ADT, nearly four hours into the flood tidal cycle, and tracked until recovery at 22:31 ADT. This drogue paralleled the second drogue track just slightly further away from the shoreline. It traveled steadily northeast until it was east of Cairn Point, then traveled north. The average speed of this drogue was 147 cm/sec.

3.2.1.2 Summary of Water Quality Data

The summer water quality sampling for all analysis types was conducted concurrently with the drogue dispersion studies on 11 - 12 August 1998. As discussed previously, three drogues were released per tidal cycle at the ZID for both ebb and flood tides and three at the control site for the flood tide only. Water samples and CTD measurements were to be obtained at a minimum of three stations along each drogue's track prior to its grounding. However, high current speeds at the ZID site and the close proximity of the Within ZID and ZID boundary stations required that the sampling scheme be altered slightly. Sampling at the Within ZID stations was accomplished prior to drogue release. The drogues were then released at the outfall and the ZID boundary and nearfield stations were taken along the drogue path.

Table 12 provides a summary of the water quality measurements obtained. Consult Table 5 for an explanation of the alphanumeric station designations.

The waters of the inlet are extremely well-mixed both vertically and horizontally, as indicated by the CTD data. During the survey, temperatures ranged from a minimum of 13.05°C to a maximum of 14.44°C. Salinities were found to vary from a minimum of 2.12 ppt to a maximum of 9.09 ppt. Salinities were generally found to increase slightly during the flood and decrease on the ebb, as is typical for estuaries. Dissolved Oxygen (DO) values ranged from 9.28 to 10.24 mg/L.



Output From TIDE1 RISE AND FALL, Micronautics, Inc. (C) 1998

Figure 8. Tidal Information For Receiving Water Sampling, Control Tides.

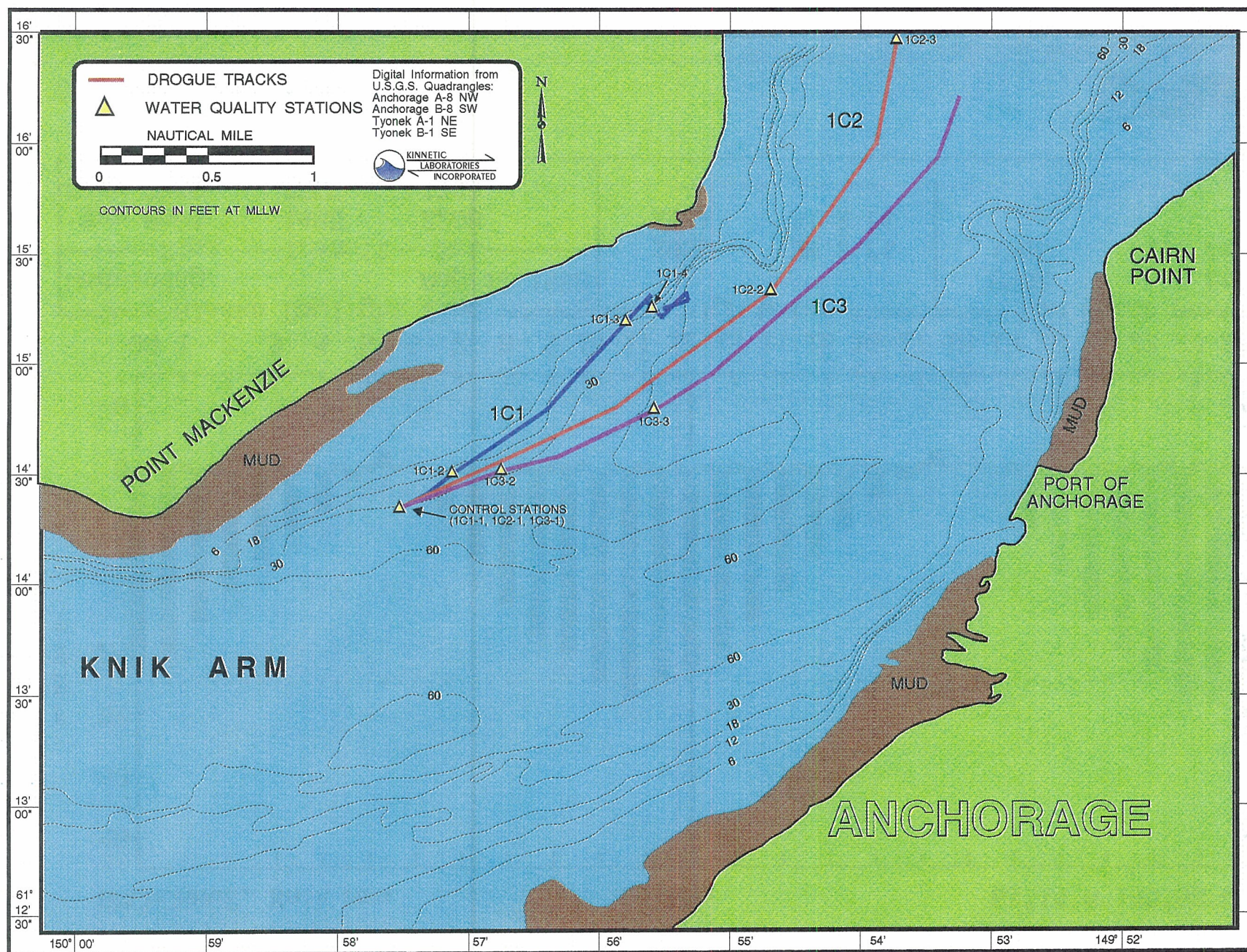


Figure 9. Summary of Control Drogue Tracks and Receiving Water Sampling Locations at Point MacKenzie, 12 August 1998.

Table 12. Hydrographic and Water Quality Data, 11 - 12 August 1998.

Station Number	Time (ADT)	Latitude (North)	Longitude (West)	Depth (M)	Temp. (°C)	Salinity (‰)	pH (units)	D.O. (mg/L)	Turbidity (NTU)	Color (units)	Cl ₂ Residual (mg/L)	Fecal Coliform ^a	Enterococci ^a
AUGUST 11													
1E1-1SW	1050	61° 12' 20.23"	150° 01' 20.04"	0.5	13.46	4.32	7.58	9.48	238	5	<0.005	>16.0	14.6
-1MW				6.5	13.91	8.22	7.98	9.38	391				
-1BW				13.0	13.91	8.22	7.99	9.41	401				
1E1-2SB	1108	61° 12' 17.37"	150° 01' 43.70"	0.5	13.05	4.91	7.92	9.58	285	10	<0.005	>16.0	9.7
-2MB				8.0	13.95	8.67	7.99	9.68	342				
-2BB				16.5	13.96	8.73	8.00	9.66	436				
1E1-3SN	1145	61° 11' 06.10"	150° 04' 15.26"	0.5	13.93	7.07	7.98	9.46	324	5	<0.005	>16.0	2.0
-3MN				2.5	14.00	8.94	7.99	9.41	286				
-3BN				5.0	14.01	9.09	7.98	9.87	397				
1E1-4SN	1203	61° 10' 43.82"	150° 05' 14.73"	---	---	---	---	---	---	10 ^m	<0.005	>16.0	11.0
1E2-1SW	1249	61° 12' 20.84"	150° 01' 15.94"	0.5	13.39	5.11	7.88	9.61	359	5	<0.005	16.0	8.5
-1MW				6.5	13.94	7.95	7.99	9.60	366				
-1BW				12.5	13.94	7.95	8.00	9.71	333				
1E2-2SB	1307	61° 12' 20.12"	150° 01' 20.34"	0.5	13.75	5.15	7.78	9.76	330	10	0.030	16.0	8.4
-2MB				6.5	13.95	7.93	7.97	9.80	435				
-2BB				13.0	13.95	7.93	7.98	9.68	429				
1E2-3SN	1337	61° 11' 42.42"	150° 04' 21.65"	0.5	13.87	4.41	7.92	9.59	405	5	<0.005	>16.0	5.2
-3MN				6.0	13.99	8.02	7.99	9.62	371				
-3BN				11.5	13.99	8.04	8.00	9.62	402				

Table 12. Hydrographic and Water Quality Data, 11-12 August 1998. (continued)

Station Number	Time (ADT)	Latitude (North)	Longitude (West)	Depth (M)	Temp. (°C)	Salinity (‰)	pH (units)	D.O. (mg/L)	Turbidity (NTU)	Color (units)	Cl ₂ Residual (mg/L)	Fecal Coliform'	Enterococci'
1E3-1SW	1424	61° 12' 20.63"	150° 01' 16.11"	0.5	13.71	4.65	7.99	9.74	377	5	0.020	>16.0	9.6
-1MW				3.0	13.96	7.74	8.00	9.81	401				
-1BW				5.5	13.96	7.73	8.01	9.80	411				
1E3-2SB	1434	61° 12' 20.84"	150° 01' 16.83"	0.5	13.53	6.23	7.97	9.85	376	5	<0.005	5.1	8.4
-2MB				3.5	13.99	7.70	7.98	9.79	370				
-2BB				6.5	13.99	7.70	7.99	9.91	390				
1E3-3SN	1456	61° 12' 04.46"	150° 02' 30.29"	0.5	14.06	6.25	7.98	9.66	387	5	0.020	>16.0	6.3
-3MN				4.5	14.06	7.74	7.99	9.47	359				
-3BN				9.0	14.01	7.69	8.00	9.65	442				
1F1-1SW	1710	61° 12' 20.74"	150° 01' 17.36"	0.5	14.25	6.33	7.94	9.46	208	15	0.150	>1600	20.6
-1MW				2.0	14.40	6.83	7.75	9.57	427				
-1BW				3.5	14.44	6.61	7.69	9.97	231				
1F1-2SB	1722	61° 12' 20.87"	150° 01' 11.37"	0.5	14.26	7.64	7.96	9.52	160	15	0.100	16.0	7.4
-2MB				1.5	14.36	7.67	7.97	9.28	110				
-2BB				3.0	14.38	7.77	7.97	9.59	131				
1F1-3SN	1810	61° 12' 13.32"	149° 59' 41.77"	0.5	14.09	5.71	7.96	9.61	98	15	<0.005	9.2	8.5
-3MN				2.5	14.23	7.13	7.96	9.57	330				
-3BN				4.5	14.21	7.08	7.96	9.59	270				
1F1-4SN	1832	61° 12' 11.23"	149° 59' 44.43"	---	---	---	---	---	---	5	<0.005	9.2	3.1

Table 12. Hydrographic and Water Quality Data, 11-12 August 1998. (continued)

Station Number	Time (ADT)	Latitude (North)	Longitude (West)	Depth (M)	Temp. (°C)	Salinity (‰)	pH (units)	D.O. (mg/L)	Turbidity (NTU)	Color (units)	Cl ₂ Residual (mg/L)	Fecal Coliform*	Enterococci*
1F2-1SW	1908	61° 11' 19.89"	150° 01' 16.64"	0.5	14.10	5.35	7.96	9.40	293	10	0.070	16.0	9.5
-1MW				4.0	14.33	7.98	7.97	9.55	294				
-1BW				8.0	14.33	7.98	7.98	9.53	289				
1F2-2SB	1926	61° 12' 20.56"	150° 01' 10.40"	0.5	13.97	2.93	7.77	10.18	326	25	<0.005	30.0	10.4
-2MB				6.0	14.03	7.45	7.97	10.24	411				
-2BB				12.0	14.03	7.46	7.99	9.63	305				
1F2-3SN	1959	61° 12' 53.95"	149° 57' 30.89"	0.5	14.03	4.80	7.85	9.93	344	5	<0.005	4.0	8.3
-3MN				6.0	13.99	7.37	7.99	10.11	465				
-3BN				12.5	14.03	7.47	8.01	9.77	415				
1F3-1SW	2037	61° 12' 20.01"	150° 01' 16.93"	0.5	13.82	4.16	7.58	10.00	308	15	<0.005	16.0	7.2
-1MW				7.0	14.04	8.08	7.96	9.73	429				
-1BW				13.5	14.04	8.08	7.98	10.04	401				
1F3-2SB	2100	61° 12' 21.53"	150° 01' 08.10"	0.5	13.82	5.78	7.84	9.72	309	10	0.020	2.2	6.3
-2MB				7.0	14.07	8.29	7.97	9.96	362				
-2BB				13.5	14.07	8.29	7.96	10.15	353				
1F3-3SN	2138	61° 13' 14.42"	149° 57' 13.93"	0.5	13.59	8.55	7.84	9.91	327	10	<0.005	16.0	8.5
-3MN				18.5	14.08	8.61	7.97	10.05	321				
-3BN				36.5	14.08	8.59	7.97	9.69	296				

Table 12. Hydrographic and Water Quality Data, 11-12 August 1998. (continued)

Station Number	Time (ADT)	Latitude (North)	Longitude (West)	Depth (M)	Temp. (°C)	Salinity (‰)	pH (units)	D.O. (mg/L)	Turbidity (NTU)	Color (units)	Cl ₂ Residual (mg/L)	Fecal Coliform*	Enterococci*
AUGUST 12													
1C1-1SR	1745	61° 14' 24.29"	149° 57' 34.21"	0.5	13.70	4.98	8.06	9.84	199	5	<0.005	5.1	<1.0
-1MR				2.0	13.70	6.12	8.05	9.63	188				
-1BR				3.5	13.71	6.14	8.05	10.01	273				
1C1-2SR	1805	61° 14' 33.70"	149° 57' 09.80"	0.5	14.07	2.12	8.04	10.04	201	<5	<0.005	2.2	2.0
-2MR				2.5	13.66	5.99	8.03	10.06	211				
-2BR				5.0	13.60	6.03	8.04	10.06	370				
1C1-3SR	1830	61° 15' 14.26"	149° 55' 49.92"	0.5	13.96	4.43	8.05	10.07	88	5	<0.005	5.1	3.1
-3MR				2.0	13.97	6.05	8.05	9.79	260				
-3BR				4.0	13.84	6.05	8.05	9.65	428				
1C1-4SR	1852	61° 15' 18.10"	149° 55' 37.18"	---	---	---	---	---	---	10	<0.005	2.2	1.0
1C2-1SR	1948	61° 14' 25.16"	149° 57' 29.01"	0.5	14.03	5.14	8.01	9.80	241	5	<0.005	5.1	1.0
-1MR				4.5	14.03	6.74	8.02	9.74	217				
-1BR				8.5	14.04	6.70	8.04	9.88	234				
1C2-2SR(A)	2022	61° 15' 22.35"	149° 54' 42.17"	0.5	13.91	7.00	7.92	9.66	383	5	<0.005	5.1	3.1
-2SR(B)	2024			0.5	14.00	7.00	7.91	9.96	382	5	<0.005	2.2	4.1
-2SR(C)	2026			1.0	13.97	6.99	7.83	10.11	401	5	<0.005	5.1	2.0
-2MR				24.0	13.87	6.92	8.00	9.64	449				
-2BR				48.0	13.78	6.63	8.02	9.94	488				

Table 12. Hydrographic and Water Quality Data, 11-12 August 1998. (continued)

Station Number	Time (ADT)	Latitude (North)	Longitude (West)	Depth (M)	Temp. (°C)	Salinity (‰)	pH (units)	D.O. (mg/L)	Turbidity (NTU)	Color (units)	Cl ₂ Residual (mg/L)	Fecal Coliform ^a	Enterococci ^a
1C2-3SR	2050	61° 16' 54.86"	149° 53' 33.40"	0.5	13.76	4.17	7.61	9.65	413	5	<0.005	2.2	1.0
-3MR				12.5	13.86	6.83	8.01	9.54	420				
-3BR				25.0	13.84	6.79	8.02	9.54	420				
1C3-1SR(A)	2131	61° 14' 23.59"	149° 57' 30.20"	0.5	14.30	4.25	7.84	10.06	302	5	<0.005	9.2	1.0
1C3-1SR(B)				---	---	---	---	9.69	294	5	<0.005	2.2	2.0
1C3-1SR(C)				---	---	---	---	9.54	337	5	<0.005	5.1	2.0
-1MR				6.0	14.28	7.68	7.98	9.74	277				
-1BR				11.5	14.12	7.61	8.00	9.60	340				
1C3-2SR	2146	61° 14' 38.09"	149° 56' 21.16"	0.5	13.86	4.13	7.85	9.61	220	10	0.010	<2.2	1.0
-2MR				12.0	14.13	7.69	8.00	9.72	324				
-2BR				24.5	14.05	7.53	8.02	9.57	347				
1C3-3SR	2203	61° 15' 00.23"	149° 55' 10.00"	0.5	13.79	3.34	7.57	9.62	314	10	<0.005	5.1	2.0
-3MR				22.0	14.04	7.80	7.99	9.61	391				
-3BR				44.0	14.02	7.83	8.00	9.59	401				

^a Fecal Coliform and Enterococci Reported as #/100 mL

--- Samples Not Collected

Values for pH ranged from 7.57 to 8.06 with no vertical stratification. Turbidity values for water samples collected during the monitoring ranged from a low of 88 Nephelometric Turbidity Units (NTUs) to a high of 488 NTUs.

Representative hydrographic profiles of water quality are presented for the second control drogue drop, Station 1C2-2, and the ZID boundary station on the first ebb drogue, Station 1E1-2 (Figure 10). The water column was found to be generally well-mixed from the surface to the bottom at all stations. Refer to Appendix C for hydrographic profile plots from each water quality station.

Dissolved oxygen data were collected *in-situ* by the CTD as well as by performing the Winkler titration on water samples collected using the Niskin bottles. The DO results tabulated and summarized in the body of this report were those obtained using the Winkler method, as called for by the Permit. The DO values obtained with the CTD are provided in Appendix C of this report.

Surface samples were obtained at each station for the analysis of color, Total Residual Chlorine (TRC), and fecal coliform and enterococci bacteria. Color values ranged from <5 to 25 color units on the platinum-cobalt scale. The maximum of 25 color units was seen once at station 1F2-2SB; other values were all below 15 color units.

Most TRC concentrations were at or below the detection limit of 0.005 mg/L. Most exceptions to this occurred during the ebb and flood tides at Point Woronzof; one station of the control sampling showed a TRC concentration higher than the detection limit. During the ebb tide at the Point Woronzof, TRC was detected above the detection limit at three stations (1E2-2SB, 1E3-1SW, and 1E3-3SN). The maximum TRC detected at these three stations was 0.030 mg/L. For the flood stations, TRC was seen above the detection limits at four stations: 1F1-1SW (0.150 mg/L), 1F1-2SB (0.100 mg/L), 1F2-1SW (0.070 mg/L), and 1F3-2SB (0.020 mg/L). The only TRC concentration seen above the detection limit at the control sites was found at Station 1C3-2SR (0.010 mg/L). It should be noted that the method detection limit achievable for TRC analysis is higher than the State-specified limit of 0.002 mg/L (for salmonid fish). The average TRC concentration of the effluent as reported in the Monthly Monitoring Report for the sampling dates 11 - 12 August 1998 was 0.8 mg/L for both days. An effluent sample collected at the same time as the bacterial stream sampling had a TRC concentration of 1.5 mg/L.

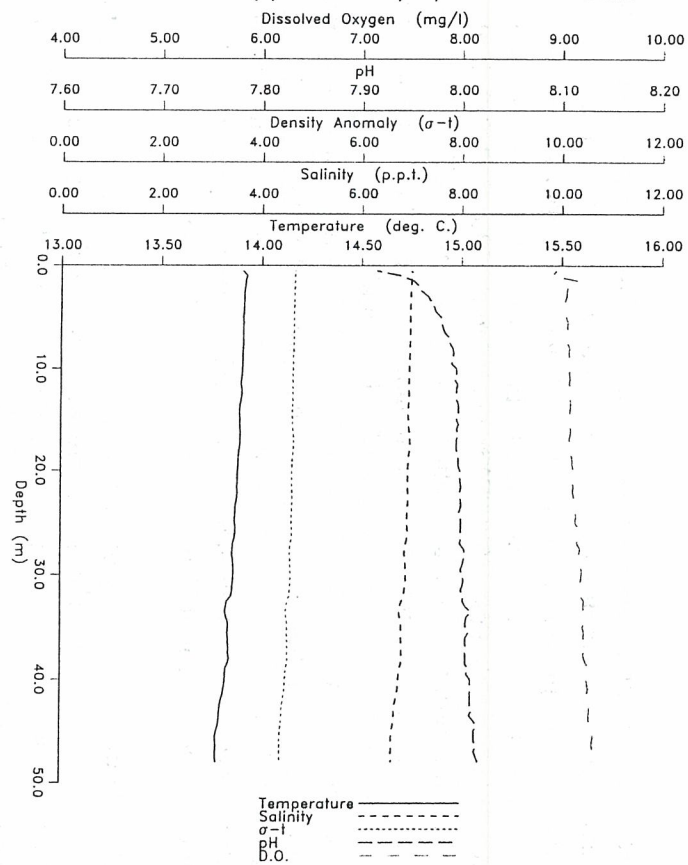
Fecal coliform values ranged from <2.2 to >1600 FC/100 mL. Most large values were reported as >16.0 FC/mL, with only two values reported at higher levels. Outfall station values during the ebb tide ranged from 5.1 to >16.0 FC/100 mL, with the majority of values at >16.0 FC/100 mL. Most outfall station values during the flood tide fell between 2.2 and 16.0 FC/100 mL. A value of 30 FC/100 mL was reported for Station 1F2-2SB, and a value of >1600 FC/100 mL was reported at Station 1F1-1SW. Control station fecal coliform counts were lower and ranged from <2.2 to 9.2 FC/100 mL.

Enterococci bacteria concentrations were also quite low, ranging from <1.0 to 20.6 MPN/100 mL. Concentrations ranged from 2.0 to 14.6 and 3.1 to 20.6 MPN/100 mL at the outfall stations on the ebb and flood tides, respectively. The highest value was seen at Station 1F1-1SW. Control station values ranged from <1.0 to 4.1 MPN/100 mL.

CONTROL STATION

MOA HYDROGRAPHIC DATA

Station: 1C2-2(A) Date: 8/12/98 Time: 20:22



OUTFALL STATION

MOA HYDROGRAPHIC DATA

Station: 1E1-2 Date: 8/11/98 Time: 11:08

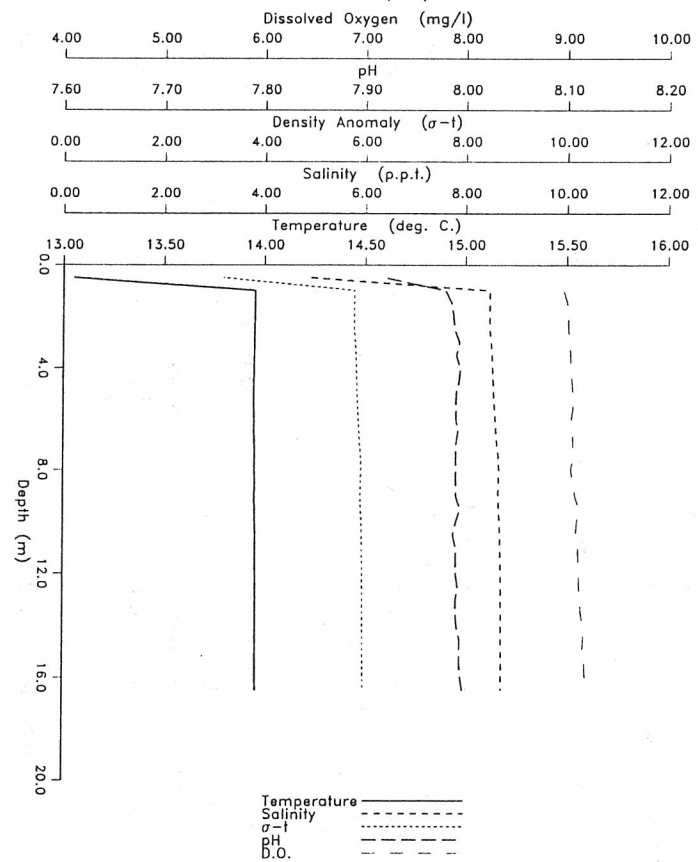


Figure 10. Sample Hydrographic Profiles from Control and Outfall Stations, August 1998.

In addition to routine monitoring conducted at each water quality station, supplemental surface samples were collected from the first three stations along the first drogue trajectory for the ZID and control floods. A sample of final effluent was also obtained at the same time for comparison. Supplemental samples were analyzed for total aromatic hydrocarbons (TAH) defined as benzene, ethylbenzene, toluene, and total xylenes (BETX-EPA Method 602); polycyclic aromatic hydrocarbons (GC/MS SIM); aliphatic hydrocarbons (GC/FID); and dissolved and total recoverable trace metals, and cyanide.

Metals, cyanide, and TSS results for these samples are presented in Table 13. Metals concentrations were quite variable, and differences between the outfall and control sites did not appear to exist with the possible exceptions of dissolved cadmium, copper, mercury, nickel, lead, and zinc. Dissolved copper, lead, and zinc concentrations were considerably higher at Station 1F1-1SW than at other outfall flood and control stations, while dissolved mercury was considerably higher at Station 1F1-2SB than at other outfall and control stations. No differences between stations were exhibited in the total recoverable metals concentrations. Metals concentrations are discussed in Section 5.2.1. Cyanide results from the ambient water stations were all below the detection limit of $2\text{ }\mu\text{g/L}$. The cyanide concentration reported for the effluent samples was $42\text{ }\mu\text{g/L}$. Total suspended solid results ranged from 170 to 480 mg/L at the control stations and from 240 to 390 at the outfall stations. The TSS value reported for the effluent sample was 70 mg/L.

Hydrocarbon analyses results are presented in Table 14. Total aromatic hydrocarbons as BETX (EPA Method 602) was determined by summing benzene, ethyl benzene, toluene, and total xylenes and are not true totals. Total aromatic hydrocarbons at the water quality stations were below the detection limit of $0.5\text{ }\mu\text{g/L}$ at all but one station. Total aromatic hydrocarbons at Station 1C1-2SR was reported at $4.4\text{ }\mu\text{g/L}$, well below the receiving water standard of $10\text{ }\mu\text{g/L}$. The effluent sample had a concentration of $24.4\text{ }\mu\text{g/L}$, an order of magnitude less than the MAEC of $250\text{ }\mu\text{g/L}$.

In addition to the standard hydrocarbon scans, full scan GC/MS was used to identify specific aliphatic and polycyclic aromatic hydrocarbon compounds in the effluent sample and seawater samples from stations along drogue tracks 1F1 and 1C1. For ease of reporting, some of these values are provided in ng/L rather than $\mu\text{g/L}$; each value can be divided by 1000 to convert the values to $\mu\text{g/L}$. Total hydrocarbons as aliphatics (GC/FID) ranged from 103 to 12,599 ng/L at the receiving water stations. The concentration of total aliphatics for the effluent was 511,174 ng/L. Two of the six receiving water stations had an unresolved complex mixture (UCM) concentration reported above the detection limit at $42.2\text{ }\mu\text{g/L}$ (Station 1C1-1SR) and $228.5\text{ }\mu\text{g/L}$ (Station 1F1SW). The effluent concentration of UCM was $11,913\text{ }\mu\text{g/L}$. The PAH concentrations in the receiving water ranged from 46 to 324 ng/L, well below the new State standard of 15,000 ng/L ($15\text{ }\mu\text{g/L}$) for total aqueous hydrocarbons (TAqH). The PAH concentration was 3,544 ng/L in the effluent sample. Effluent concentrations were well below the MAEC of 375,000 ng/L ($375\text{ }\mu\text{g/L}$) for TAqH if the standard were applied to the current NPDES Permit for Point Woronzof.

Coprostanol and cholesterol concentrations were also determined in the receiving water and effluent. These two sterols, indicative of pollution by sewage or human waste, appear elevated at the ZID stations as compared to control. Coprostanol was reported to be below method detection limits at all three control stations. Coprostanol reported at the flood stations ranged from 1,281 to 81,193

Table 13. Concentrations of Dissolved Metals, Total Recoverable Metals, Cyanide, and Total Suspended Solids in Receiving Water and Effluent Samples. Values have not been blank corrected.

Station	Method	Ag	As	Be	Cd	CN	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn	TSS
		$\mu\text{g/L}$							ng/L	$\mu\text{g/L}$						mg/L
1F1-1SW (WITHIN ZID)	Dissolved	0.0117	1.07	0.3 U	0.0701	NA	0.175	5.08	0.764	0.875	0.0461	0.4 U	0.2 U	0.0089	4.04	NA
	Recoverable	0.0097	6.53	0.3 U	0.146	ND	12.7	26.2	57.1	14.6	6.05	0.704	0.2 U	0.0665	48.7	390
1F1-2SB (ZID BOUNDARY)	Dissolved	0.0088	0.889	0.3 U	0.0404	NA	0.137	1.15	1.85	0.578	0.0097	0.4 U	0.2 U	0.0100	0.992	NA
	Recoverable	0.0088	5.12	0.3 U	0.0980	ND/ND ^a	9.41	15.1	26.4	10.4	3.61	0.596	0.2 U	0.0548	29.4	290/280 ^a
1F1-3SN (NEAR FIELD)	Dissolved	0.0088	0.991	0.3 U	0.0384	NA	0.170	0.904	0.432	0.629	0.0086	0.4 U	0.2 U	0.0103	0.747	NA
	Recoverable	0.0088	3.94	0.3 U	0.0739	ND	6.53	10.8	19.1/19.2 ^a	7.37	2.59	0.664	0.2 U	0.0408	20.4	240
1C1-1SR	Dissolved	0.0088	0.785	0.3 U	0.0217	NA	0.124	0.462	0.478	0.456	0.0056	0.4 U	0.2 U	0.0086	0.598	NA
	Recoverable	0.0058	7.24	0.3 U	0.111	ND	13.8	23.2	41.3	15.8	5.73	1.00	0.2 U	0.0698	43.9	480
1C1-2SR	Dissolved	0.0088	0.850	0.3 U	0.0261	NA	0.135	0.486	0.423	0.483	0.0086	0.4 U	0.2 U	0.0094	1.09	NA
	Recoverable	0.0058	6.28	0.3 U	0.0887	ND	10.7	17.4	30.7	12.1	4.07	0.641	0.2 U	0.0546	33.4	170
1C1-3SR	Dissolved	0.0058	0.824	0.3 U	0.0284	NA	0.127	0.529	0.717	0.502	0.0073	0.4 U	0.2 U	0.0102	0.900	NA
	Recoverable	0.0088	5.08	0.3 U	0.0724	ND	8.48	14.0	25.3	9.67	3.24	0.740	0.2 U	0.0475	26.7	410
	Recoverable ^a	0.0058	4.73	NA	0.0726	NA	7.65	13.3	NA	8.90	3.18	NA	0.2 U	0.0446	24.7	NA
EFFLUENT	Dissolved	0.0088	3.38	0.3 U	0.225	NA	0.741	29.0	6.75	3.23	0.452	0.425	0.2 U	0.0061	33.6	NA
	Dissolved ^a	NA	3.17	0.3 U	0.209	NA	0.688	27.6	NA	3.15	0.391	0.412	NA	0.0058	31.1	NA
	Recoverable	0.199	4.67	0.3 U	0.357	42	2.48	41.3	146	3.50	6.31	0.742	1.78	0.0014	67.3	70
	Recoverable ^a	0.190	4.48	0.3 U	0.313	NA	2.17	41.0	NA	3.35	6.43	0.749	1.51	0.0023	64.9	NA
DETECTION LIMIT	Dissolved	0.0051	0.02	0.3	0.006	NA	0.02	0.01	0.016	0.006	0.003	0.4	0.2	0.002	0.08	NA
	Recoverable	0.0051	0.02	0.3	0.006	2.0	0.02	0.01	0.016	0.006	0.003	0.4	0.2	0.002	0.08	1.0

Analyte Abbreviations: Ag (silver), As (arsenic), Be (beryllium), Cd (cadmium), CN (cyanide), Cr (chromium), Cu (copper), Hg (mercury), Ni (nickel), Pb (lead), Sb (antimony), Se (selenium), Tl (thallium), Zn (zinc), TSS (total suspended solids)

^a Laboratory duplicate
 NA Not applicable/available
 ND None detected
 U Not detected at or above detection limit

Table 14. Supplemental Receiving Water and Effluent Hydrocarbon Analyses.

Parameter	Control Flood Samples			ZID Flood Samples			Effluent
	1C1-1SR	1C1-2SR	1C1-3SR	1F1-1SW ^a	1F1-2SB	1F1-3SN	
Volatile Organics (EPA 602) in $\mu\text{g/L}$; detection limit 0.5 $\mu\text{g/L}$							
Benzene	ND	1.8	ND	ND/ND	ND	ND	1.3
Toluene	ND	2.1	ND	ND/ND	ND	ND	8.5
Chlorobenzene	ND	ND	ND	ND/ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND/ND	ND	ND	0.95
Xylenes	ND	0.55	ND	ND/ND	ND	ND	5.9
1,2 Dichlorobenzene	ND	ND	ND	ND/ND	ND	ND	1.1
1,3 Dichlorobenzene	ND	ND	ND	ND/ND	ND	ND	ND
1,4 Dichlorobenzene	ND	ND	ND	ND/ND	ND	ND	6.6
Total Aromatics	ND	4.4	ND	ND/ND	ND	ND	24.4
Aliphatic Hydrocarbons by GC/FID							
Total Alkanes (ng/L)	346.6	103.3	312.2	12598.6	353.4	299.6	511174.3
Unresolved Complex Mixture (UCM) ($\mu\text{g/L}$)	42.2	21.6 J	7.3 J	228.5	ND	ND	11912.8
Polycyclic Aromatic Hydrocarbons (PAH) by GC/MS in ng/L							
Total PAH (without Perylene)	231.2	46.0	83.8	323.9	96.6	81.9	3543.9
Sterols by GC/MS in ng/L							
Coprostanol	12.1 J	16.1 J	15.5 J	81192.7	1539.0	1281.2	1573915.7
Cholesterol	58.9	164.0	6.5 J	10610.5	213.5	652.1	344009.8

^a Duplicate field sample analysis provided (value/duplicate value)

ND None detected

J Below method detection limit

ng/L. Cholesterol ranged from below detection limits to 164 ng/L at the control stations and from 214 to 10,610 ng/L at the outfall stations. Effluent concentrations were 1,573,916 and 344,010 ng/L for coprostanol and cholesterol, respectively.

3.2.2 Intertidal Zone and Stream Bacterial Sampling

Intertidal zone and stream bacteriological sampling was performed on 11 August 1998. Intertidal zone sampling began approximately one and a quarter hours prior to high tide at 21:21 ADT and was completed at 22:02 ADT. Two replicates were taken at all intertidal stations. Stream sampling was conducted from 18:07 to 18:50 ADT. In addition, an effluent sample was collected at the plant at 17:25 ADT. A summary of the sampling results is presented in Table 15. Refer to Figure 3 for a map of the station locations.

Fecal coliform concentrations ranged from 2.2 to 23.0 FC/100 mL at the intertidal stations. One replicate at Station IT-5 was reported at >16.0 FC/100 mL. Concentrations at the outfall, Station IT-0, were 16.0 and 9.2 FC/100 mL for the two replicates. Fecal coliform concentrations found in the streams ranged from 23.0 FC/100 mL at Chester Creek to 300 FC/100 mL at Fish Creek. The plant effluent sample taken on the same day just prior to the creek sampling was analyzed in duplicate and showed values of >16.0 and 140 FC/100 mL. Fecal coliform concentration in the control samples (Station IT-C4, Replicates 1 and 2) were 9.2 and 5.1 FC/100 mL.

Results of the enterococci bacterial analyses showed intertidal values ranging from 1.0 to 6.3 MPN/100 mL. Station IT-0, at the outfall, had enterococci values of 3.1 and 1.0 MPN/100 mL for the two replicates obtained. Fish Creek showed an enterococci value of 204 MPN/100 mL, while Ship and Chester Creeks showed lower values of 34.5 and 4.1 MPN/100 mL, respectively. The enterococci concentration in the effluent collected in conjunction with the intertidal sampling was reported at >2,419.2 MPN/100 mL for both the sample and the duplicate. The control station (IT-C4) had enterococci concentrations of 1.0 and 6.3 MPN/100 mL for the two replicates obtained.

Table 15. Summary of Bacterial Analyses, 11 August 1998.

Intertidal Station and Replicate	Sample Time (ADT)	Fecal Coliform FC/100 mL	Enterococci MPN/100 mL
IT-0 Replicate 1	21:50	16.0	3.1
IT-0 Replicate 2	21:50	9.2	1.0
IT-1 Replicate 1	21:47	7.0	5.2
IT-1 Replicate 2	21:47	23.0	6.3
IT-2 Replicate 1	21:43	9.2	2.0
IT-2 Replicate 2	21:43	5.1	1.0
IT-3 Replicate 1	21:39	17.0	5.2
IT-3 Replicate 2	21:39	17.0	4.1
IT-4 Replicate 1	21:34	4.0	3.1
IT-4 Replicate 2	21:34	13.0	2.0
IT-5 Replicate 1	21:54	>16.0	2.0
IT-5 Replicate 2	21:54	16.0	3.1
IT-6 Replicate 1	21:57	2.2	1.0
IT-6 Replicate 2	21:57	16.0	4.1
IT-7 Replicate 1	22:02	9.2	3.1
IT-7 Replicate 2	22:02	9.2	2.0
IT-C4 Replicate 1	21:21	9.2	1.0
IT-C4 Replicate 2	21:21	5.1	6.3
Plant Effluent	17:25	>16.0	>2419.2
Plant Effluent (duplicate)	17:25	140	>2419.2
Fish Creek	18:07	300	204
Chester Creek	18:30	23.0	4.1
Ship Creek	18:50	30.0	34.5

4.0 QUALITY ASSURANCE/QUALITY CONTROL

4.1 OBJECTIVES

The objective of the Quality Assurance/Quality Control (QA/QC) program is to ensure that the data collected are of sufficiently high quality to be comparable with the quality of data from other EPA-regulated NPDES programs and to develop documentation to provide an assurance of the data quality.

The following definitions apply:

- **Quality Assurance** - Comprises planned and systematic actions, including audits and corrective actions, necessary to provide adequate confidence in the results of the sampling program.
- **Quality Control** - Comprises those actions that provide a means to control and measure the characteristics of equipment and processes to established requirements or tolerances.

4.2 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

4.2.1 Documentation

Field data sheets were used to record both field data and QA/QC program data. Field logs for each program component (hydrographic profiling, drogue tracking, etc.) were printed on waterproof plastic paper and supplied to the field crew in three-ring binders. Completed field data sheets for the water quality monitoring are included in Appendix D.

4.2.2 Station Locations

Primary vessel positioning was accomplished by using a Differential Global Positioning System (DGPS). The swift currents of Cook Inlet inhibited vessel station-keeping and required the use of methods that accomplished sampling very quickly. Niskin water bottles were lowered on three separate lines to their appointed depths (surface, middle, and near-bottom) and tripped with messengers. The CTD was lowered to the bottom at the same time to achieve simultaneous measurements. In addition to the DGPS navigation fixes, secondary fixes were obtained by visual sightings. Since the vessel was close to shore, in most cases, distances to prominent landmarks were approximated. If needed, more accurate distances could be obtained with the vessel's radar. These secondary fixes prove useful as a check in the event of any data irregularities. An absolute check on navigational accuracy was obtained by fixing on the diffuser location at low tide.

4.2.3 Field Instrumentation and Sampling Quality Assurance/Quality Control Procedures

For influent, effluent, and sludge monitoring, duplicate effluent samples were collected for analysis of total aromatic hydrocarbons (EPA 602), total hydrocarbons as oil and grease, pesticides, and selenium during the Summer-dry sampling. During the Summer-wet sampling, duplicate effluent samples were collected for metals (antimony, molybdenum, selenium, and thallium), total aromatic hydrocarbons (EPA 602), and total petroleum hydrocarbons. Results for these analyses are provided in Tables 6 and 7 and the appendices.

During the receiving water sampling, conductivity, temperature, and depth (CTD) profiles were obtained with a Seabird SEACAT SBE-19 recording oceanographic profiling system. This instrument also provided pH and DO measurements. Salinity and density were calculated from conductivity, temperature, and depth data. The CTD was equipped with a submersible pump to facilitate adequate flow across the sensors. The instrument was calibrated prior to field use, following the manufacturer's instructions contained in the users manuals, using laboratory or electronic standards.

Water samples and CTD profiles were taken simultaneously, with the former being analyzed in the laboratory except TRC, which was analyzed onboard the survey vessel. Sampling variability for water quality parameters (DO, fecal coliform, enterococci bacteria, color, TRC, and turbidity) was determined by analyzing three surface samples taken at Station 1C2-2SR (Table 16). Where appropriate, the mean, standard deviation, and coefficient of variation are included in Table 16 to provide a measure of variability for the listed parameters.

Variability and calibration checks of the electronics probe were done by performing repeated profiles of temperature, pH, and salinity at one station (1C2-2SR). Results of these calibration checks for the Seabird probe show that probe variability for temperature, pH, and salinity was extremely low (Table 17). In addition, salinity data obtained from the CTD were compared with six salinity grab samples that were collected during the receiving water monitoring survey. Hydrographic data from the CTD can be compared with grab sample results (Appendix C). In addition, a precision thermometer was used to verify CTD temperature readings, *in-situ* DO readings from the CTD were compared with Winkler titration results, and the pH sensor was calibrated against three standards prior to field deployment.

Results from duplicate field samples collected for certain parameters during the receiving water sampling such as volatile organics (EPA Method 602), cyanide, and TSS are reported in the appropriate tables (Tables 13 and 14).

Field blanks were collected for several parameters during each sampling event by pouring HPLC-grade deionized (DI) water into the appropriate sampling containers with the correct preservative. Trip blanks consisted of DI blank samples prepared at the laboratory that went through the same shipping and handling procedures as all the other sample containers of each analytical type; these remained unopened in the field. Field blanks and trip blanks analyzed using EPA Method 602 during the Summer-dry and Summer-wet samplings showed no measurable levels of the target compounds (Appendix B). Trip blanks analyzed in conjunction with the EPA 624 analyses for Summer-dry and Summer-wet showed no detectable levels of the target compounds (Appendices B). However, the field blanks collected for EPA 624 during both the Summer-dry and Summer-wet samplings showed measurable levels of methylene chloride. The source of these contaminants is unknown as they were not detected in the associated method blanks or trip blanks, and introduction during sampling is unlikely. The most likely source is laboratory contamination as methylene chloride is a common laboratory solvent and is often seen in laboratory quality control samples.

Field blanks were collected during the water quality sampling only for the aromatic hydrocarbons (EPA 602). This sample showed a toluene concentration of $0.77 \mu\text{g/L}$ (Appendix C). No toluene contamination was detected in the method blank for this sample set.

Table 16. Sampling and Laboratory Variability for Water Quality Samples, 11 - 12 August 1998.

Station Number	Subsample Designation	Dissolved Oxygen mg/L	Fecal Coliform FC/100 mL ^a	Enterococci MPN/100 mL ^a	Color Units	Turbidity NTU	Chlorine Residual mg/L
SAMPLING VARIABILITY							
Effluent	---	---	>16.0[8.0-Infinite]	>2419.2[---]	---	---	---
Effluent Duplicate	---	---	140[8.0-Infinite]	>2419.2[---]	---	---	---
1C2-2SR	A	9.66	5.1 [0.5-19.2]	3.1[1.0-15]	5	383	<0.005
	B	9.96	2.2 [0.1-12.6]	4.1[1.0-20]	5	382	<0.005
	C	10.11	5.1 [0.5-19.2]	2.0[1.0-11]	5	401	<0.005
Mean 1C2	---	9.91	---	---	5	388.7	<0.005
Std. Dev. 1C2	---	0.23	---	---	0	10.7	0
Coeff. of Var. (%) 1C2	---	2.31	---	---	0	2.8	0
LABORATORY VARIABILITY							
1C3-1SR	A	10.06	9.2[1.6-29.4]	1.0[---]	5	302	<0.005
	B	9.69	2.2[0.1-12.6]	2.0[1.0-11]	5	294	<0.005
	C	9.54	5.1[0.5-19.2]	2.0[1.0-11]	5	337	<0.005
Mean 1C3	---	9.76	---	---	5	311	<0.005
Std. Dev. 1C3	---	0.27	---	---	0	22.87	0
Coeff. of Var. (%) 1C3	---	2.74	---	---	0	7.35	0

^a 95% Confidence intervals indicated in brackets (American Public Health Association, 1989 & 1992. Standard methods for the Examination of Water and Wastewater. 17th & 18th Editions. Washington, D.C. Tables 9221.III [1989] and 9221.IV [1992]).

--- Not applicable

Table 17. Seabird SEACAT SBE-19 CTD Probe Variability Check, 12 August 1998.

Depth (m)	Temperature (°C)			Salinity (ppt)			pH (units)			Mean (units)			Standard Deviation (units)			Coeff. Of Variation (%)		
	2A	2B	2C	2A	2B	2C	2A	2B	2C	TEMP	SAL	pH	TEMP	SAL	pH	TEMP	SAL	pH
1C2- 1.0	13.93	13.95	13.97	6.99	7.00	6.99	7.94	7.94	7.83	13.95	7.00	7.90	0.024	0.007	0.062	0.169	0.100	0.782
3.0	13.91	13.91	13.92	6.98	6.99	7.00	7.97	7.96	7.87	13.92	6.99	7.93	0.006	0.011	0.054	0.040	0.152	0.676
5.0	13.91	13.91	13.92	6.97	6.97	6.99	7.98	7.98	7.92	13.91	6.98	7.96	0.005	0.012	0.037	0.035	0.175	0.464
7.0	13.91	13.88	13.91	6.97	6.90	6.99	7.99	7.99	7.97	13.90	6.95	7.98	0.020	0.049	0.009	0.145	0.700	0.109
9.0	13.91	13.84	13.92	6.96	6.79	6.99	7.99	8.00	7.99	13.89	6.91	7.99	0.041	0.107	0.003	0.293	1.554	0.036
11.0	13.90	13.85	13.91	6.95	6.83	6.99	7.99	8.00	8.00	13.89	6.92	8.00	0.035	0.084	0.004	0.253	1.207	0.051
13.0	13.90	13.83	13.91	6.95	6.77	6.99	8.00	8.01	8.00	13.88	6.90	8.00	0.042	0.115	0.005	0.303	1.664	0.063
15.0	13.89	13.85	13.91	6.94	6.82	6.99	8.00	8.00	8.00	13.89	6.92	8.00	0.034	0.087	0.003	0.243	1.264	0.036
17.0	13.90	13.84	13.91	6.97	6.81	6.98	8.00	8.00	8.00	13.88	6.92	8.00	0.034	0.096	0.004	0.248	1.392	0.052
19.0	13.89	13.87	13.90	6.94	6.83	6.96	8.00	8.00	8.00	13.89	6.91	8.00	0.016	0.071	0.002	0.119	1.030	0.022
21.0	13.88	13.88	13.90	6.93	6.92	6.95	8.00	8.00	8.00	13.89	6.93	8.00	0.009	0.016	0.001	0.066	0.236	0.007
23.0	13.88	13.87	13.88	6.94	6.87	6.92	8.00	8.00	8.00	13.88	6.91	8.00	0.007	0.035	0.000	0.049	0.505	0.000
25.0	13.87	13.89	13.87	6.92	6.95	6.89	8.00	8.00	8.01	13.88	6.92	8.00	0.010	0.029	0.004	0.074	0.412	0.045
27.0	13.86	13.87	13.89	6.90	6.91	6.93	8.00	8.00	8.00	13.87	6.91	8.00	0.014	0.016	0.001	0.097	0.236	0.007
29.0	13.86	13.87	13.83	6.89	6.90	6.78	8.00	8.00	8.01	13.85	6.86	8.00	0.021	0.066	0.003	0.152	0.957	0.038
31.0	13.86	13.87	13.83	6.89	6.90	6.77	8.00	8.00	8.01	13.85	6.85	8.00	0.017	0.071	0.004	0.126	1.041	0.045
33.0	13.83	13.83	13.83	6.78	6.80	6.75	8.01	8.00	8.01	13.83	6.78	8.01	0.001	0.030	0.003	0.008	0.435	0.037
35.0	13.84	13.82	13.83	6.82	6.73	6.75	8.01	8.01	8.01	13.83	6.77	8.01	0.009	0.043	0.003	0.065	0.639	0.036
37.0	13.84	13.82	13.83	6.82	6.74	6.75	8.01	8.01	8.01	13.83	6.77	8.01	0.010	0.044	0.003	0.071	0.644	0.036
39.0	13.83	13.82	13.81	6.78	6.74	6.70	8.01	8.01	8.01	13.82	6.74	8.01	0.009	0.042	0.003	0.065	0.628	0.031
41.0	13.82	13.82	13.81	6.75	6.72	6.71	8.01	8.01	8.01	13.82	6.73	8.01	0.002	0.021	0.003	0.013	0.309	0.036
43.0	13.80	13.82	13.81	6.68	6.73	6.72	8.01	8.01	8.01	13.81	6.71	8.01	0.010	0.026	0.004	0.074	0.384	0.044
45.0	13.78	13.81	13.82	6.64	6.70	6.72	8.01	8.01	8.01	13.80	6.68	8.01	0.016	0.043	0.003	0.118	0.646	0.038

4.3 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

4.3.1 Laboratory Precision

For Summer-dry and Summer-wet sampling events, duplicative laboratory analyses are reported in the appropriate tables (Tables 6 and 7). Full analytical data are provided in Appendix B.

In addition to the standard laboratory QC procedures, color, fecal coliform, enterococci, turbidity, DO, and TRC samples collected at Station 1C3-1SR during the receiving water sampling were analyzed in triplicate. Mean, standard deviation, and coefficient of variation are reported in Table 16 for these samples (where appropriate). These statistics were not determined for fecal coliform and enterococci due to nature of the analysis which yields only a most probable number of bacteria per 100 mL. Instead, the $\pm 95\%$ confidence limits for each sample are estimated in Table 16 (from APHA, 1992).

Metals were analyzed in duplicate for several of the receiving water samples, as indicated in Table 13 and Appendix C. In addition, the effluent sample was analyzed in duplicate for both fecal coliform and enterococci.

4.3.2 Laboratory Accuracy

EPA-approved methods were used for all routine plant monitoring, analyses of water quality parameters, and toxic pollutant analyses. Attendant laboratory QA/QC procedures were followed. The QA/QC procedures utilized spikes or surrogate recoveries, standard reference materials, sample splits, and method blanks to assure the quality of the analytical results. Detailed QA/QC results for laboratory analyses are provided in Appendices B and C with the corresponding analyses.

Matrix spikes and matrix spike duplicate samples are those samples that are fortified with components of interest following the initial analysis to check the ability of the method to recover acceptable levels and to determine accuracy of the data. A similar type of quality control sample used for organic pollutants analysis is the laboratory control spike, a sample of known, interference-free matrix that is analyzed with each batch of samples. A laboratory control spike duplicate is also analyzed. These types of analyses may also be performed on blank material (blank spike and blank spike duplicate). Results for these analyses are provided with individual data reports (Appendices B and C).

Surrogates are compounds that are added to each sample that was analyzed by GC/MS methods, such as EPA 624/8260, EPA 625/8270, GC/FID, and GC/MS SIM, or for pesticides. Surrogate recovery results are also used as an estimate of the accuracy of the results and are provided on individual data reports (Appendices B and C).

Trace metals analyses for the receiving water testing were supported through the use of Standard Reference Materials (SRMs), which are quality control reference materials with known metals values that are obtained from the National Bureau of Standards. These SRMs are analyzed by the laboratories at the same time as the project samples in order to ensure laboratory accuracy. Results of the analyses of SRM's should fall within acceptable limits and can be expressed as percent recovery as in:

$$\% \text{ Recovery} = \frac{(\text{measured concentration})}{(\text{actual concentration})} \times 100$$

Total recoverable metals SRM, matrix spike, and method blank results for Summer-dry and -wet influent and effluent samples are provided in Appendix B and for total recoverable and dissolved metals in receiving water samples in Appendix C. In addition, an SRM was also analyzed for TSS and cyanide receiving water samples (Appendix C).

Method blanks (or procedural blanks) were also analyzed for most analyses. Method blanks consist of pure, organic- or metal-free reagent water that is run through the analysis process and used to verify that analyte concentrations are accurate and do not reflect contamination. The method blank results showed no contamination for either the Summer-dry or Summer-wet analyses.

Method blank results for the receiving water sampling were more varied. The method blank analyses for metals showed very small amounts of the various metals, some of which were present at levels below detection limits (Appendix C). Similarly, small amounts of hydrocarbons were detected in the procedural blanks analytes performed in conjunction with the supplemental hydrocarbon analyses GC/MS SIM and GC/FID (Appendix C). This is typical for low-level analyses such as these and does not adversely affect data quality. The method blank analyses performed with the TSS and cyanide analyses showed no results above method detection limits.

For routine parameters, the following summary of QA/QC procedures apply:

- Dissolved Oxygen Samples: The titrant used was standardized and checked on duplicate reference samples daily. The titrant strength was rechecked during the analyses.
- Fecal Coliform Bacteria: *Escherichia coli* was used as a positive control for each analytical run. *Pseudomonas aeruginosa* was used as a negative control and buffered dilution water was used as a blank. All blanks run for fecal coliform bacteria showed no growth.
- Enterococci Bacteria: *Streptococcus faecalis* was used as a positive control for each analytical run. *Escherichia coli* was used as a negative control and buffered dilution water was used as a blank. All blanks for enterococci bacteria showed no growth.
- Color: Fresh color standards were made prior to the beginning of the project and duplicates were run every ten samples. Duplicate results were all within acceptable limits and ranged from 0 to 20 RPD. Due to the high turbidity, all samples were filtered prior to analysis. Color results were reported as either true or apparent color depending on whether turbidity could be completely removed.
- Turbidity: The instrument was calibrated with a DI water blank and a 22.6 NTU standard provided by the manufacturer. Instrument calibration was checked every 20 samples.
- Total Residual Chlorine: TRC was run by amperometric titration which requires a blank and laboratory control and laboratory control spike samples every ten samples. Due to instrumentation drift these QC steps were performed every four samples.

- Trace Metals and Cyanide (AWWU Laboratory): Analyses were run on samples with known concentrations of each metal and anion. Laboratory blanks were run with each batch of analyses.
- Salinity: A seawater salinity standard was used to check the instrumental accuracy every half-hour or every ten samples, whichever was more frequent.
- Analytical Balance: Accuracy was checked using Class S weights.

In addition to the supplemental QC samples analyzed as part of the monitoring program, each laboratory utilized for the project implemented their own internal QA/QC procedures. These procedures included the calibration and maintenance of equipment, personnel training procedures, analytical methodology, QC samples (blanks, duplicates, check samples, matrix spikes, etc.), documentation procedures, and Standard Operating Procedures (SOPs).

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5.0 DISCUSSION

5.1 INFLUENT, EFFLUENT, AND SLUDGE MONITORING

Toxic pollutant and pesticide analyses during 1998 were conducted on 18 - 19 June (Summer-dry) and 11 - 12 August (Summer-wet). These sampling events were in addition to AWWU's self-monitoring program that was performed on a daily, weekly, and monthly basis depending on the parameter measured.

In 1986, EPA published revised "Quality Criteria for Water". These revised criteria are not always directly comparable to the 1980 and 1976 criteria because they are based on different exposure periods of various aquatic organisms to the toxicant. The State of Alaska adopted the 1986 criteria as water quality standards on 7 January 1987. In March 1996, the State of Alaska water quality regulations were further revised. The NPDES Permit for the Point Woronzof treatment plant requires compliance with applicable State water quality standards. However, since the new criteria were not in effect at the time of Permit issuance, they are not applicable during this Permit period and are not used in this report.

The applicable State regulations are found in Chapter 70 of the Alaska Administrative Code entitled "Water Quality Standards" (18 AAC 70; ADEC, 1989). This chapter requires that criteria outlined in "Quality Criteria for Water" (EPA, 1976) be met in applicable receiving waters at every point outside of State and Federal effluent discharge mixing zone boundaries.

Table 18 lists Permit effluent limitations and water quality criteria that were in effect in 1985 at the time of Permit issuance; it includes each of the toxic pollutants required to be monitored in the Point Woronzof NPDES Permit. The values shown are the chronic toxicity criteria for salt water aquatic life. Chronic toxicity criteria concentrations are lower than acute toxicity criteria concentrations; therefore, the most stringent of the two were used for comparison. Based on the outfall design criteria, a dilution factor of 25:1 was applied to the water criteria to determine the Maximum Allowable Effluent Concentration (MAEC). It was assumed that the final effluent would be diluted by a minimum factor of 25 by the time it reaches the boundary of the Zone of Initial Dilution (ZID). *In situ* measurements of dilution were conducted during 1988 and indicated measured dilutions in the range of 50:1 to 200:1 and model predictions of 38:1 at the ZID (CH2M Hill, 1988).

To determine compliance with State water quality standards, Table 18 can be compared with effluent values found in Tables 6 through 9. Most values from the effluent sampling at Point Woronzof were found to be much lower than the water quality standards. The only MAEC that was exceeded during the toxic pollutant and pesticide sampling was the total hydrocarbons as oil and grease. In addition, detailed PAH and BETX analyses were conducted which indicated low levels of TAqH in the effluent (27.9 $\mu\text{g/L}$) as required by the revised Alaska State Water Quality Standards (3/16/96). The marine water use standard is specified for the "growth and propagation of fish, shellfish, other aquatic life, and wildlife" (18 AAC 70).

For "contact recreation", the State water quality criteria for hydrocarbons is as follows: "Shall not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters shall be virtually free from floating oils."

Table 18. NPDES Requirements, State of Alaska Water Quality Standards and AWWU 1998 Maximum Concentrations for Effluent Comparisons. Non-compliant values are shown in bold type.

Parameter	Receiving Water Quality Standard ^a ($\mu\text{g/L}$)		Maximum Allowable Effluent Concentration ^b (MAEC)($\mu\text{g/L}$)	AWWU 1998 Maximum Effluent Concentration ($\mu\text{g/L}$)
Antimony	146	Human health, not listed for saltwater aquatic life	3,650	ND (10) ^c
Arsenic	508	Acute toxicity to saltwater aquatic life	12,700	26 ^d
Beryllium	11	For the protection of aquatic life in soft fresh water	275	<0.1 ^d
Cadmium	4.5	Saltwater aquatic life (24 hour average)	112	6 ^d
Chromium	18	Saltwater aquatic life (24 hour average)	450	16 ^d
Copper	4	Saltwater aquatic life (24 hour average)	100	60 ^d
Lead	25	Chronic toxicity to saltwater aquatic life	625	21 ^d
Mercury	0.025	Saltwater aquatic life (24 hour average)	0.625	<0.2 ^d
Nickel	7.1	Saltwater aquatic life (24 hour average)	177	40 ^d
Selenium	54	Saltwater aquatic life (24 hour average)	1,350	ND (10) ^c
Silver	2.3	Saltwater aquatic life (24 hour average)	57	11.1 ^d
Thallium	2130	Acute toxicity to saltwater aquatic life	53,250	ND (10) ^c
Zinc	58	Saltwater aquatic life (24-hour average)	1,450	88 ^d
Cyanide	2	For marine aquatic life	50	20 ^d
Total Hydrocarbons as Oil and Grease	15	Growth and propagation of fish, shellfish, aquatic life, and wildlife including seabirds, waterfowl, and furbearers ^e	375	30,000^c
Total Aromatic Hydrocarbons as BETX	10	Same as above ^e	250	20.7 ^c
Monthly Average Flow Rate	<i>f</i>		44 MGD ^g	30.7 MGD ^{d,g}

Table 18. NPDES Requirements, State of Alaska Water Quality Standards, and AWWU 1997 Maximum Concentrations for Effluent Comparisons. (continued) Non-compliant values are shown in **bold type**.

Parameter	Receiving Water Quality Standard ^a	Maximum Allowable Effluent Concentration ^b (MAEC)	AWWU 1997 Maximum Effluent Concentration
pH	<i>e</i>	6.5 - 8.5 (pH units)	6.5 - 7.9 (pH units) ^d
Total Residual Chlorine	<i>e</i>	Monthly Avg. 1.2 mg/L Daily Avg. Max. 1.4 mg/L	Monthly Avg. 0.9 mg/L ^d Daily Avg. Max. 1.0 mg/L ^d
BOD ₅	<i>e</i>	Monthly Avg. 120 mg/L Weekly Avg. 130 mg/L Daily Max. 140 mg/L	Monthly Avg. 121 mg/L ^d Weekly Avg. 129 mg/L ^d Daily Max. 159 mg/L ^d
Suspended Solids	<i>e</i>	Monthly Avg. 100 mg/L Weekly Avg. 115 mg/L Daily Max. 130 mg/L	Monthly Avg. 55 mg/L ^d Weekly Avg. 65 mg/L ^d Daily Max. 83 mg/L ^d
Fecal Coliform	<i>e</i>	Monthly Geometric Mean shall not exceed 850 and not more than 10% of samples shall exceed 2600 FC MPN/100 mL.	Monthly Geometric Mean did not exceed 44. The criterion of not more than 10% of samples exceeding 2600 FC MPN/100 mL was met this year. ^d

^a EPA 1976. Quality Criteria for Water, U.S. Environmental Protection Agency, Washington, D.C. 10460, U.S. Government Printing Office: 1977, 0-222-904.

EPA 1980. Ambient Water Quality Criteria listed under Section 304(a)(1) of the Clean Water Act, October 1980, EPA 440/5-90-015 through EPA 440/5-90-079, Office of Water Regulations and Standards, Criteria and Standards Division, Washington, D.C. 20470.

^b Effluent water quality criteria were determined by assuming a dilution of 25:1 at the ZID boundary; pollutant concentrations in the effluent should not exceed these values

^c Values from Summer-wet/Summer-dry samplings

^d Values from MOA's Monthly Monitoring Reports

^e Alaska Administrative Code. Water Quality Standards, Chapter 70 (18 AAC 70)

^f MAEC's are not based on water quality criteria but instead are specified in MOA's NPDES Permit

^g Million gallons/day

The laboratory method specified by ADEC, at the time of Permit issuance (1985), for total hydrocarbons (SM 503B) is actually an infrared method for oil and grease. In 1998, this method was supplemented with the EPA 1664 HEM method due to the unavailability of freon required by the SM 503B method. These oil and grease methods do not measure a specific substance, but instead quantify groups of substances such as mineral hydrocarbons, biological lipids, sulfur compounds, certain organic dyes, chlorophyll, etc. As a consequence, samples that are run by these methods have much higher concentrations of "total hydrocarbons" by ADEC's definition. Also, these methods have much higher reporting or detection limits than the State-specified receiving water quality standard of 15 $\mu\text{g/L}$.

Total hydrocarbons as oil and grease in the effluent reported for the Summer-dry and Summer-wet sampling ranged from 20,200 to 32,000 $\mu\text{g/L}$ as determined by the EPA 1664 HEM method. Oil and grease determined by the SM503B method ranged from 25,000 to 30,000 $\mu\text{g/L}$. Good agreement between these methods was seen in both the influent and effluent during the Summer-dry and Summer-wet sampling events (Tables 6 and 7).

Recent revisions to the State of Alaska water quality standard regulations will address these problems with changes in terminology and methods (ADEC, 1996), and these changes in regulations will be addressed by the revised Permit when one is issued. The revised water quality standards were legally put into effect on 16 March 1996. The new regulations call for the removal of the old definition of "total hydrocarbons" determined by SM 503B and the use of new "total aqueous hydrocarbons" and "total aromatic hydrocarbons" categories instead. The existing water quality criteria of 15 $\mu\text{g/L}$ will be used for the new classification of total aqueous hydrocarbons. Total aqueous hydrocarbons include dissolved and water-borne monoaromatic and polynuclear aromatic hydrocarbons that can be separated from larger droplets and surface oils using gravity separation techniques. The new regulations indicate that total aqueous hydrocarbons may be determined using a combination of methods. These include gas chromatographic flame ionization detection methods (GC/FID), EPA Method 610, or other methods approved by ADEC for quantifying polynuclear aromatic hydrocarbons. The new regulations recommend the use of EPA Method 602 plus xylenes for total aromatic hydrocarbons, defined as the sum of the volatile monoaromatic hydrocarbons. The water quality criteria of 10 $\mu\text{g/L}$ will be applied to this category of hydrocarbons.

Oil and grease was also measured in the effluent by the Point Woronzof Laboratory on a monthly basis using gravimetric analyses (SM 5520B) or EPA 1664 HEM (in May, June, and July 1998 only). Individual concentrations in 1998 ranged from 25,500 to 32,500 $\mu\text{g/L}$ during the 12-month reporting period, with a yearly average of 24,100 $\mu\text{g/L}$ (Table 9).

Supplemental analyses for hydrocarbons were also performed on the effluent during the Summer-dry and wet toxic pollutant and pesticide samplings and the summer receiving water sampling. Total petroleum hydrocarbon (SM 503E/EPA 418.1) concentration in the effluent was 4,000 and 4,100 $\mu\text{g/L}$ for the Summer-dry sampling (two analyses) and 2,600 $\mu\text{g/L}$ during the Summer-dry sampling (for three analyses; Tables 6 and 7). Total petroleum hydrocarbons in both the influent and effluent as determined by the EPA 1664 SGT-HEM method were all below detection limits of 10,000 $\mu\text{g/L}$.

During the receiving water sampling, the effluent was analyzed for petroleum hydrocarbons by GC/FID and for PAH by GC/MS SIM methodology. Total aliphatics measured in the effluent were 511 $\mu\text{g/L}$ and total PAHs were 3.5 $\mu\text{g/L}$. The total aliphatics and total PAHs were both substantially

less than the allowable MAEC of 375 $\mu\text{g/L}$ for total hydrocarbons and 250 $\mu\text{g/L}$ for total aromatic hydrocarbons. Total aromatic hydrocarbons as BETX (EPA Method 602) were measured in the effluent and found to be below the MAEC of 250 $\mu\text{g/L}$ (Tables 6 and 7). Concentrations were approximately 10 $\mu\text{g/L}$ for Summer-dry and approximately 21 for Summer-wet. During the receiving water sampling, the effluent had a BETX concentration of 24 $\mu\text{g/L}$ (EPA 602; Table 14).

The types and concentrations of measured organic compounds varied between the two sampling periods. This is probably the result of different point sources discharging into the Municipality's wastewater system at various times. Also, in some instances, large differences in pollutant concentrations occurred between the influent and effluent. Inconsistencies can be explained by looking at sampling methodology and plant operation in the case of point-source contaminants. If spikes of contaminants are occurring in the influent, these might be hit or missed during sampling. On the other hand, an effluent sample could contain the contaminant because of mixing in the clarifiers. Differences in concentrations in influent and effluent samples could also be due to lower suspended sediment and particulate in the effluent samples. This can be seen in Table 8, where greater variability usually occurs in the influent concentrations as compared to the effluent.

When the MAECs in Table 18 were compared to AWWU's self-monitoring heavy metals and cyanide data (Appendices A and B), no constituent exceeded their MAECs. In a number of the past years, maximum concentrations of cyanide have been near the MAEC of 50 $\mu\text{g/L}$. During this sampling year the highest monthly value was 20 $\mu\text{g/L}$. During the receiving water sampling, the cyanide concentration in the effluent was reported at 42 $\mu\text{g/L}$ (Table 13).

During previous years, copper would at times exceed the MAEC of 100 $\mu\text{g/L}$. However, during the 1998 reporting period, the highest value found for copper in the effluent was 60 $\mu\text{g/L}$. The reasons for the elevated copper concentrations in previous years were investigated and reported to the Municipality by CH2M Hill and the AWWU laboratory. The conclusion of the copper investigation was that most of the copper in the influent wastewater is from the Municipal water source and is not a significant component of industrial discharge (CH2M Hill, 1987 and 1988). Neither enforcement of the sewer ordinance (AMC 26.50) nor the industrial pretreatment program was expected to significantly reduce the amounts of copper received at the Point Woronzof facility. The mass of copper in the plant influent and effluent remained fairly constant from 1986 through 1991. From 1991 to 1992, the in-plant copper loading dropped by approximately twenty-five percent. The exact cause of this decrease is unknown, however, an increase in pH (to 8.0) at the Water Treatment Facilities (Ship Creek and Eklutna) during the Spring of 1991 caused a decrease in copper concentrations taken from "first draw" residential water sources in Anchorage. This increase in alkalinity was implemented to reduce corrosion in the drinking water distribution system. It would follow that these decreased values in drinking water would also affect the influent concentrations.

Influent, effluent, and sludge samples are analyzed for "total" metals as specified in Anchorage's NPDES Permit rather than "total recoverable" metals. This presents a problem when comparing concentrations found in Anchorage's effluent to the MAECs and to other POTWs that are using the standard "total recoverable" techniques. Thus, Anchorage's analyses for "total metals" will result in higher concentrations than those determined by "total recoverable" analysis techniques. The difference in concentrations between these two techniques are somewhat site specific and have not been determined for MOA's effluent discharge.

Another problem of comparing effluent metals concentrations to the MAECs is that the Federal water quality criteria used to calculate the MAECs are based upon acid-soluble metals concentrations. EPA states that acid-soluble metals concentrations would provide a more scientifically-correct basis for metals (EPA, 1986). More recently, EPA has issued a number of documents which recommend the use of dissolved metals methodology as the best method of determining the concentrations of bioavailable metals and which also indicate that total recoverable measurements may result in overestimating the toxicity (EPA, 1992; 1993; 1994). Since the EPA water quality criteria are based on total recoverable and acid-soluble methodologies, the resulting criteria need to be adjusted downwards to obtain dissolved metals criteria. For example, during freshwater acute toxicity testing, EPA determined that 86 percent of the total recoverable copper concentration was the result of dissolved copper (EPA, 1992). The toxicity of metals associated with particulate matter, however, is not necessarily zero, so total recoverable concentrations should still be determined. The effluent sample collected during the receiving water sampling was analyzed for both total "dissolved metals" and for "total recoverable metals" (Table 13). Concentrations were found to be significantly lower by dissolved methods than by either "total metals" or "total recoverable" methodology.

In addition to the MAECs based on the State and Federal water quality criteria, a number of other effluent limitations are specified in the NPDES Permit. These daily, weekly, and monthly limitations include flow rate, BOD₅, total suspended solids, and TRC (Table 18). All of these parameters except BOD₅ were found to be within their limitations for the entire reporting period. Refer to Table 9 for monthly averages and to Appendices A and B for daily and weekly data. The BOD₅ daily maximum criterion of 140 mg/L was exceeded three times during the reporting period: November 1997 (159 and 144 mg/L) and July 1998 (144 mg/L). The weekly average criteria of 130 mg/L was not exceeded during the reporting period. The monthly average criteria of 120 mg/L for BOD₅ was exceeded once during October 1997 (121 mg/L).

For fecal coliform bacteria, the Permit states that "not more than 10% of the samples shall exceed 2,600 FC MPN/100 mL" during any month and the geometric mean shall not exceed 850 for any month. These limitations were never exceeded during the reporting period. The highest monthly geometric mean was 44 FC MPN/100 mL, and only two individual sample results exceeded the 2,600 FC MPN/100 mL limit.

Under the amendments to the Clean Water Act (40 CFR; Final Rule, 8/9/94), dischargers with 301(h) waivers are required to remove 30% of the BOD₅ and 30% of the suspended solids. When the Point Woronzof discharge Permit is renewed, these BOD₅ and suspended solid removal rates will be required, and the plant is already performing at well above these levels. Removal of BOD₅ was 54% for the 12-month reporting period (Table 9), the same as reported last year. Recent years have shown considerable improvement over past performance. For example, during the latter part of the 1990 monitoring year, the BOD₅ removal was 37%. For 1992, the average BOD₅ removal was 52%, and in 1993, the removal increased to 54% and has been near that level since. The average total suspended solids removal for this 12-month reporting period was 80%, about the same as the last four years and well above the anticipated requirement of 30%.

Increased removal of BOD₅ and total suspended solids shown over the last few years is due to a number of factors. The influent autosampler in use prior to January 1991 was found to be collecting non-representative samples. Comparison of results for samples collected from the permanently

installed autosampler and a portable sampler indicated that the existing autosampler was collecting samples lower in BOD₅ and suspended solids. During the period of January through July 1991, the portable autosampler was used for influent sampling while a new sampling system was designed and installed. The new permanent autosampler, brought online during August 1991, is essentially a permanent version of the portable sampler installed at the headworks. This autosampler is believed to be providing more representative samples than the sampler in use prior to January 1991, as it continues to collect samples showing higher BOD₅ and total suspended solid concentrations. The primary reason that this autosampler is more effective in collecting representative samples is that it provides higher line velocity and shorter transit time than the obsolete system, leading to less settling of solids during sampling. In addition, operational changes have been made which may affect percent removal rates for both BOD₅ and total suspended solids, including changes in thickener loading and dewatering procedures, sample line cleaning, and a general increase in the number of clarifiers in use.

Concentrations of toxic pollutants and pesticides detected in the influent and final effluent were compared with data from an EPA study of 40 Publicly Owned Treatment Works (POTWs) in Table 19 (EPA, 1982). *Values are within the range of those detected in other POTWs from across the nation, even though the Point Woronzof Plant provides only primary treatment as compared to secondary treatment provided at the other plants.* The same holds true for metals and cyanide monitored within the plant; the 1998 values for metals and cyanide concentrations were lower than or within the range of those detected in POTWs providing secondary treatment.

Similar comparisons can be made for levels of toxic pollutants and pesticides in sludge (Table 20). Again, *data indicate that concentrations of toxic pollutants and pesticides in Anchorage sludge are generally lower than "typical" concentrations in other POTWs.* An exception to this was the arsenic concentrations found in the sludge with a yearly average of 18.1 $\mu\text{g/g}$. This value was nearly doubled from last year's average of 9.4 $\mu\text{g/g}$. It exceeded the typical concentration as reported in the table (4.6 $\mu\text{g/g}$) but was lower than the 95th percentile concentration of 20.77 $\mu\text{g/g}$. The high average for arsenic this year was the result of an extremely elevated arsenic concentration (257 mg/kg) reported for one sampling during July 1998; an additional arsenic analysis performed during July 1998 showed a more typical value of 14.5 mg/kg. The average mercury concentration in sludge for the 1998 reporting year was just over the typical concentration of 1.49 $\mu\text{g/g}$ at 1.5 $\mu\text{g/g}$. A number of monthly mercury concentrations (Table 10) were above the typical concentration level but were well below 95th percentile concentrations.

There are no sludge limitations in the current Permit; however, under the new sludge regulations (40 CFR Part 503), limitations may be required when the Permit is reissued. Allowable concentrations were calculated by CH2M Hill (1993) based on formulas presented in Part 503. The allowable concentration of arsenic in sludge was calculated to be 95.8 $\mu\text{g/g}$, substantially higher than the yearly average of 18.1 $\mu\text{g/g}$. Other allowable concentrations of metals in sludge that were calculated were found to be substantially higher than concentrations measured at the Point Woronzof Plant.

Levels of toxic pollutants and pesticides detected in the Anchorage effluent this year and over the last 10 years are shown in Table 21. These data indicate some variability over time, but a generally similar pattern overall. Levels are low and often below reporting limits.

Table 19. Comparison Between Influent/Effluent Analysis Results for Anchorage and 40 POTWs.^a Values in brackets indicate results from EPA Method 602.

Parameter	Anchorage Values				40 POTW Study Values				
	1998 Concentration ^b (μg/L)				Frequency of Detection (%)		Range Detected (μg/L)		Influent Median
	Summer-Dry		Summer-Wet		Influent	Secondary Effluent	Influent	Secondary Effluent	(μg/L)
	INF ^c	EFL ^{c,d}	INF	EFL ^d					
VOLATILES									
Toluene	9.18[8.1]	8.60[6.4/63]	12[17]	9.5[8.0/8.0]	96	53	1-13000	1-1100	27
Ethylbenzene	0.12 ^e [ND]	ND[0.51/0.51]	1.5[0.8]	ND[1.5/1.5]	80	24	1-730	1-49	8
Total Xylenes	NT[2.8]	NT[2.6/2.6]	NT[4.4]	NT[9.8/9.9]	NA	NA	NA	NA	NA
Benzene	0.18 ^e [0.74]	ND[0.70/0.70]	ND[1.8]	ND[1.3/1.3]	61	23	1-1560	1-72	2
Chloroform	2.69	2.96	3.0	3.3	91	82	1-430	1-87	7
Tetrachloroethene	1.82	1.50	6.6	3.2	95	79	1-5700	1-1200	23
Methylene Chloride	3.56	3.35	6.3	7.2	92	86	1-49000	1-62000	38
1,2-Dichlorobenzene	ND[0.79]	ND[1.3/1.4]	ND[3.1]	ND[1.9/0.7]	23	8	1-440	1-27	NA
1,4-Dichlorobenzene	1.45[4.2]	1.18[4.3/4.2]	ND[3.1]	ND[8.8/9.9]	17	3	2-200	3-9	NA
SEMI-VOLATILES ^f									
bis(2-Ethylhexyl)phthalate	19 J	9.6 J	18	15	92	84	2-670	1-370	27
Phenol	37	ND	18	12	79	29	1-1400	1-89	7
METALS & OTHER COMPONENTS									
Antimony	ND	ND	ND	ND/ND	14	13	1-192	1-69	NA
Arsenic	4	3	34	13	15	12	2-80	1-72	NA
Beryllium	ND	ND	ND	ND	3	1	1-4	1-12	NA
Cadmium	ND	ND	ND	ND	56	28	1-1800	2-82	3
Chromium	ND	ND	ND	ND	95	85	8-2380	2-759	105
Copper	100	60	92	49	100	91	7-2300	3-255	132
Lead	11	3	13	8	62	21	16-2540	20-217	53
Mercury	0.6	0.1	0.35 ^g	ND ^g	70	31	0.2-4	0.2-1.2	0.517
Molybdenum	ND	ND	ND	ND/ND	NA	NA	NA	NA	NA
Nickel	10	10	30	40	79	75	5-5970	7-679	54
Selenium	ND	ND	ND	ND/ND	9	10	1-10	1-150	NA
Silver	7.6	5.7	13.8	11.3	71	25	2-320	1-30	8
Thallium	ND	ND	ND	ND/ND	3	2	1-19	1-2	NA
Zinc	145	65	187	79	100	94	22-9250	18-3150	273
Cyanide	ND	ND	ND	ND	100	97	3-7580	2-2140	249

^a Source: RPS 1982. *Fate of Priority Pollutants in POTWs*. Final Report, Volume I, Effluent Guidelines Division, WH-552, EPA 440/1-82/303

^b Data from NPDES 1998 toxic pollutant and pesticide monitoring

^c EPA 624 values are an average of all 8 samples collected with zero used for non-detects

^d Duplicate analyses provided for some analyses (value/duplicate value)

^e Averaged value is below the detection limit

^f Only analytes detected above the detection limit in either the influent or effluent are included

^g Holding time exceeded for mercury samples

J Result detected below the reporting limit or is an estimate (e.g., estimated due to matrix interference)

NA Not available

ND Not detected

NT Not tested

Table 20. Comparison Between Sludge Analysis Results for Anchorage and Typical and Worse Case Concentrations Used by EPA in Developing Median or Mean Environmental Profiles^a. All concentrations are in $\mu\text{g/g}$ dry weight.

Pollutant	1998 Anchorage Values			Typical Concentration	95 th Percentile "Worse Case"
	Summer-dry ^b	Summer-wet ^b	1998 AVG ^c		
Aldrin/Dieldrin	ND(0.029)/ND(0.057)	ND(0.027)/ND(0.055)	---	0.07	0.81
Arsenic	7.4	18.7	18.0	4.6	20.77
Benzene	ND(2.2) ^d	ND(0.81)	---	0.326	6.58
Benzo(a)anthracene	ND(26)	ND(100)	---	0.68	4.8
Benzo(a)pyrene	ND(26)	ND(100)	---	0.14	1.94
Beryllium	0.06	0.07	0.10	0.313	1.168
Bis(2-ethylhexyl)phthalate	34.0	180	---	94.28	459.25
Cadmium	3.5	3.7	3.0	8.15	88.13
Carbon Tetrachloride	ND(2.2) ^d	ND(0.81)	---	0.048	8.006
Chlordane (α,γ)	ND(0.029)/ND(0.029)	ND(0.027)/ND(0.027)	---	3.2	12
Chloroform	ND(2.2) ^d	ND(0.81)	---	0.049	1.177
Chromium	22	22	20	230.1	1499.7
Copper	239	258	229	409.6	1427
Cyanide	ND(3.13)	ND(2.53)	1.73	476.2	2686.6
DDT/DDE/DDD	ND(0.011)/ND(0.011)/ND(0.011)	ND(0.010)/ND(0.010)/ND(0.010)	---	0.28	0.93
3,3-Dichlorobenzidine	ND(130)	ND(480)	---	1.64	2.29
Methylene chloride	1.5 J ^d	ND(0.81)	---	1.6	19
Endrin	ND(0.057)	ND(0.055)	---	0.14	0.17
Hexachlorobenzene	ND(26)	ND(100)	---	0.38	2.18
Hexachlorobutadiene	ND(2.2) ^d /ND(26)	ND(0.81)/ND(100)	---	0.3	8
Lead	36	85	70	248.2	1070.8
gamma -BHC (Lindane)	ND(0.029)	ND(0.027)	---	0.11	0.22
Malathion	ND(0.071)	ND(0.069)	---	0.045	0.63
Mercury	1.5	3.43 ^d	1.5	1.49	5.84
Molybdenum	6.0	5.4	---	9.8	40
Nickel	18	21	18	44.7	662.7
PCBs	ND(0.570)	ND(0.550)	---	0.99	2.9
Pentachlorophenol	ND(130)	ND(480)	---	0.0865	30.434
Phenanthrene	ND(26)	ND(100)	---	3.71	20.69
Phenol	3.8 J	ND(100)	---	4.884	82.06
Selenium	1.9	ND(0.30)	---	1.11	4.848
Tetrachloroethene	ND(2.2) ^d	ND(0.81)	---	0.181	13.707
Trichloroethene	ND(2.2) ^d	ND(0.81)	---	0.46	17.85
2,4,6-Trichlorophenol	ND(26)	ND(100)	---	2.3	4.6
Vinyl Chloride	ND(4.3) ^d	ND(1.6)	---	0.43	311.942
Zinc	458	562	485	677.6	4580

^a Source: EPA 1985a. Summary of Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: Methods and Results, Office of Water Regulations and Standards, Appendix F.

^b Data from NPDES 1998 toxic pollutant and pesticide monitoring

^c Average from monthly in-plant monitoring results

^d Samples analyzed outside of holding time

--- Not monitored in-plant

ND () Not detected (detection limit)

NT Not tested

Table 21. Comparison of Toxic Pollutants and Pesticides in Anchorage's Final Effluent over the Last Ten Years. Values in brackets are from EPA Method 602.

Pollutant	1988		1989				1990		1991	
	Wet	Dry	Winter	Spring	Dry	Wet	Dry	Wet	Dry	Wet
	8/3	8/19	3/9	4/12	7/18	9/6	6/20	8/22	6/24, 9/4	8/8
ORGANICS ($\mu\text{g/L}$)										
Phenol	12	ND	ND	ND	ND	ND	ND	ND	ND	8
Diethyl phthalate	ND	ND	ND	ND	ND	ND	3	ND	ND	5
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND[ND]	ND[0.6]	ND[0.7]	ND[0.61]	5[3.6]	ND[1.0]	ND[ND]	ND[0.5]	3[0.6]	ND[2.3]
1,1,1-Trichloroethane	ND	1.0	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	5	ND	ND	3	3	4
Ethylbenzene	ND[4.1]	ND[1.2]	ND[1.4]	ND[1.7]	ND[2.5]	ND[1.3]	ND[ND]	ND[0.8]	ND[0.8]	ND[1.8]
Methylene Chloride	ND	ND	13	ND	27	32	ND	14	11	11
Tetrachloroethene	ND	ND	ND	15	ND	ND	ND	1	ND	ND
Toluene	10[9.6]	11[6.7]	8[6.4]	9[5.5]	17[13]	ND[7.3]	11[ND]	6[4.4]	23[6.1]	11[17]
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
* Acetone	79	93	96	47	170	ND	170	91	160	220
* 4-Methyl-2-Pentanone	ND	ND	ND	ND	ND	ND	17	ND	ND	13
* Total Xylenes	31[30]	14[9.1]	8[11.0]	15[8.9]	17[15]	10[8.6]	ND[ND]	4[4.4]	5[7.6]	12[12]
Bis-(2-ethylhexyl)phthalate	12	34	ND	ND	ND	ND	ND	ND	ND	9
Di-n-octyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
* Benzyl Alcohol	ND	23	ND	20	35	11	ND	7	8	19
* 4-Methylphenol	30	29	66	25	55	19	ND	26	12	39
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,6-Dinitrotoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-butyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
Butyl benzyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
*1,2-Dichlorobenzene	ND	ND	ND[ND]	ND[ND]	ND[ND]	ND[ND]	ND[ND]	ND[ND]	ND[ND]	ND[ND]
*1,3- & 1,4-Dichlorobenzene	ND	ND	ND[1.0]	ND[0.7]	ND[1.6]	ND[0.9]	ND[ND]	ND[2.5]	ND[ND]	ND[1.3]
* Benzoic Acid	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
* 2-Methylphenol	22	ND	ND	ND	ND	ND	ND	4	ND	ND
*2-Butanone	ND	ND	ND	23	32	ND	31	26	24	53
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	3	ND	ND
Total Hydrocarbons as Oil and Grease ^a	11000	23000	17000	38000	23000	10700	24000	12000	34000	23000
Total Petroleum Hydrocarbons ^b	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Total Aromatic Hydrocarbons as BETX	41[43.7]	25[17.6]	16[19.5]	24[16.7]	34[34.1]	11[18.2]	28[ND]	10[12.6]	31[15.1]	23[33.1]

Table 21. Comparison of Toxic Pollutants and Pesticides in Anchorage's Final Effluent over the Last Ten Years. (continued) Values in brackets are from EPA Method 602.

Pollutant	1992		1993		1994		1995	
	Dry	Wet	Dry ^d	Wet	Dry ^d	Wet ^d	Dry ^d	Wet ^{d,e}
	7/7	8/26	7/13	9/8	7/11	9/12	6/13	8/8
ORGANICS (µg/L)								
Phenol	22	12	20/20	13	23/17	ND	22/14	ND
Diethyl phthalate	9.2	9.7	15/15	8.5	15/12	ND	ND	ND
Naphthalene	ND	ND	ND/ND	2.7	ND/ND	ND	ND	ND
Benzene	ND[ND]	ND[ND]	ND[ND]	ND[0.7]	ND[0.61]	ND[0.55/0.5]	ND[ND]	2.6[1.3/1.0]
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	3.1	3.3	4.0	4.6	4.8	5.0	3.2	3.7
Ethylbenzene	ND[ND]	2.1[2.4]	ND[ND]	2.9[ND]	2.5[1.6]	ND[ND/ND]	2.0[ND]	3.0[0.5/0.5]
Methylene Chloride	7.3	6.6	ND	ND	ND	5.4	15	3
Tetrachloroethene	2.3	4.7	11	4.7	ND	ND	ND	ND
Toluene	8.0[3.6]	12[30]	11[7.8]	11[7.7]	11[8.3]	12[7.4/7.5]	13[6.1]	18[6.2/6.2]
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND
* Acetone	110	140	87	120	120	140	140	85
* 4-Methyl-2-Pentanone	11	ND	ND	ND	ND	ND	ND	ND
* Total Xylenes	4.7[0.7]	17[53]	6.3[2.5]	25[3.9]	17[14]	5.6[2.1/2.2]	12[2.0]	20.6[3.5/3.3]
Bis-(2-ethylhexyl)phthalate	ND	ND	ND/ND	ND	ND/ND	ND	ND	ND
Di-n-octyl phthalate	ND	ND	ND/ND	ND	ND/ND	ND	ND	ND
* Benzyl Alcohol	25	11	16/16	11	19/14	ND	ND	ND
* 4-Methylphenol	46	5.9	44/63	23	39/38	43	60/ND	ND
Acenaphthene	ND	ND	ND/ND	ND	ND/ND	ND	ND	ND
2,6-Dinitrotoluene	ND	ND	ND/ND	ND	ND/ND	ND	ND	ND
Pyrene	ND	ND	ND/ND	ND	ND/ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND/ND	ND	ND/ND	ND	ND	ND
Di-n-butyl phthalate	ND	ND	ND/ND	ND	ND/ND	ND	ND	ND
Butyl benzyl phthalate	ND	2.6	ND/ND	ND	ND/ND	ND	ND	ND
*1,2-Dichlorobenzene	ND[ND]	ND[ND]	ND[1.7]	ND[2.4]	ND/ND[6.3]	ND[2.9/1.4]	ND[ND]	ND[ND]
*1,3- & 1,4-Dichlorobenzene	ND[ND]	ND[1.2]	ND[4.3]	ND[5.3]	ND/ND[8.0]	ND[3.8/2.3]	ND[2.1]	ND[8.7/8.7]
* Benzoic Acid	330	270	370/430	220	330/260	98	200/ND	150
* 2-Methylphenol	ND	ND	ND/ND	ND	ND/ND	ND	ND	ND
*2-Butanone	32	36	20	21	31	33	46	31
2,4-Dimethylphenol	ND	ND	ND/ND	ND	ND/ND	ND	ND	ND
Total Hydrocarbons as Oil and Grease ^a	12000	26000	15000/16000	23000	21000/24000	11000	8400/3600	8700
Total Petroleum Hydrocarbons ^b	NT	NT	NT	NT	1300/2300	ND	840/720	800
Total Aromatic Hydrocarbons as BETX	12.7[4.3]	31.1[85.4]	17.3[10.3]	38.9[12.3]	30.5[24.5]	17.6 [10.6/10.7]	27.0[8.1]	44.2 [11.5/11.0]

Table 21. Comparison of Toxic Pollutants and Pesticides in Anchorage's Final Effluent over the Last Ten Years. (continued) Values in brackets are from EPA Method 602.

Pollutant	1996		1997		1998	
	Wet ^d 8/6-7	Dry ^d 8/16-17	Dry ^d 6/30-7/1	Wet ^d 8/19-20	Dry 6/18-19	Wet 8/11-12
ORGANICS (µg/L)						
Phenol	17.7	8.9/6.9	ND	ND	ND(9.9)	12
Diethylphthalate	4.22	3.8/3.3	5.54	ND	1.7J	ND
Naphthalene	ND	ND	NT	NT	ND	ND
Benzene	0.39[0.5/0.6]	0.47[1.0/0.9]	1.26[0.96/0.86]	ND[0.81/0.82]	ND[0.7/0.7]	ND[1.3/1.3]
1,1,1-Trichloroethane	ND	ND	7.92	ND	ND	ND
Bromodichloromethane	0.20	0.24	ND	ND	ND	ND
Chloroform	3.7	3.0	3.39	2.98	2.92	3.3
Ethylbenzene	1.29[0.6/0.6]	0.84[1.0/1.1]	1.23[0.7/0.86]	ND[ND/ND]	0.06[0.5/0.5]	ND[1.5/1.5]
Methylene Chloride	7.84	4.13	ND	6.75	3.35	7.2
Tetrachloroethene	0.59	1.45	1.19	1.42	1.50	3.2
Toluene	13.8[11/11]	10.5[11/10]	14.4[9.3/9.1]	9.09[9.4/9.5]	8.6[6.4/6.3]	9.5[8.0/8.0]
* Acetone	87 ^h	106 ^h	ND	ND	ND	ND
* 4-Methyl-2-Pentanone	NT	NT	ND	ND	ND	ND
* Total Xylenes	8.71[2.3/2.4]	6.09[3.8/4.9]	7.66[5.4/5.3]	3.60[3.3/3.2]	ND[2.6/2.6]	ND[9.8/9.9]
Bis-(2-ethylhexyl)phthalate	ND	ND	13.3	ND	9.6 J	15
Di-n-octyl phthalate	ND	ND	ND	ND	1.7 J	ND
* Benzyl Alcohol	15.0	12.3/9.8	8.97	ND	ND	ND
* 4-Methylphenol	56.7	58/49	44.0	ND	NT	NT
Acenaphthene	ND	ND	ND	ND	ND	ND
2,6-Dinitrotoluene	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND
Di-n-butyl phthalate	ND	ND/ND	ND	ND	1.3 J	ND
Butyl benzyl phthalate	ND	ND	ND	ND	1.4 J	ND
* 1,2-Dichlorobenzene	ND[ND]	ND[ND]	ND	ND	ND[1.3/1.4]	ND[1.9/0.7]
* 1,3- & 1,4-Dichlorobenzene	2.15[ND/ND]	1.5[ND]	1.12[1.6/1.5]	1.29	1.17[4.3/4.2]	ND[8.8/9.9]
* Benzoic Acid	181	201/157	ND	ND	ND	ND
* 2-Methylphenol	ND	ND	ND	ND	ND	ND
* 2-Butanone	NT	NT	ND	ND	ND	ND
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND
Total Hydrocarbons as Oil and Grease ^a	ND	10000/ND	26100	25300	25000/25000	30000
Total Petroleum Hydrocarbons ^b	ND	ND/ND	1630	1820/2090	4000/4100	2600
Total Aromatic Hydrocarbons as BETX	24.2[14.4/14.5]	17.9[16.8/16.9]	24[16.5/16.1]	14.7[14/14]	[10.21/10.11]	[20.6/20.7]

Table 21. Comparison of Toxic Pollutants and Pesticides in Anchorage's Final Effluent over the Last Ten Years. (continued) Values in brackets are from EPA Method 602.

Pollutant	1988		1989				1990		1991	
	Wet	Dry	Winter	Spring	Dry	Wet	Dry	Wet	Dry	Wet
	8/3	8/19	3/9	4/12	7/18	9/6	6/20	8/22	6/24, 9/4	8/8
METALS ($\mu\text{g/L}$)										
Antimony	ND	ND	ND	ND	ND	ND	200	<200	ND	ND
Arsenic	2	ND	2	3	4	4	3	2	6	2
Beryllium	ND	ND	ND	ND	ND	ND	<100	<100	ND	ND
Cadmium	7	ND	9	16	7	ND	0.8	<5	<5	0.7
Chromium	ND	17	4	8	ND	6	<50	<50	3	<30
Copper	100	90	90	70	90	50	52	83	70	70
*Hexavalent Chromium	NT	ND	NT	NT	NT	NT	NT	NT	NT	NT
Lead	9	19	9	8	15	10	15	17	13	18
Mercury	0.2	ND	0.4	0.3	ND	ND	0.6	<0.5	<0.3	<0.3
Molybdenum	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Nickel	4	12	7	4	2	ND	2	4	4	<20
Selenium	ND	ND	ND	ND	ND	ND	<2	<2	<2	<2
Silver	21	7	13.6	6.9	14.0	ND	7.9	8.8	8.0	8.6
Thallium	ND	ND	ND	ND	ND	ND	<200	<200	19	10
Zinc	91	100	99	104	102	72	70	104	86	120
PESTICIDES ($\mu\text{g/L}$)										
gamma-BHC (lindane)	0.03	ND	0.05	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	0.06	ND	ND	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	0.08	ND	ND	ND	ND	ND	ND	ND	ND	ND
*2,4'-DDT	NT	NT	NT	NT	NT	NT	NT	NT	0.1	ND
4,4'-DDT	0.6	ND	0.15	ND	ND	ND	ND	ND	1.0	ND
Endosulfan Sulfate	0.52	ND	ND	ND	ND	ND	ND	ND	0.3	ND
Endosulfan II	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND
OTHER										
Cyanide ($\mu\text{g/L}$)	NT	NT	5	7	5	26	14	5	8	6
Asbestos (million fibers/L) ^y	ND	ND	1	3	ND	ND	ND	ND	0.048	ND

Table 21. Comparison of Toxic Pollutants and Pesticides in Anchorage's Final Effluent over the Last Ten Years. (continued) Values in brackets are from EPA Method 602.

Pollutant	1992		1993		1994		1995	
	Dry	Wet	Dry ^d	Wet	Dry ^d	Wet ^d	Dry ^d	Wet ^{d,e}
	7/7	8/26	7/13	9/8	7/11	9/12	6/13	8/8
METALS ($\mu\text{g/L}$)								
Antimony	ND	ND	ND/ND	ND	ND/ND	ND	0.6/0.6	<0.5
Arsenic	4	2	2	13	2	10	3	2
Beryllium	ND	ND	ND	ND	ND	ND	<0.1	<0.1
Cadmium	ND	ND	ND	ND	ND	7	<5	<5
Chromium	4	ND	ND	ND	ND	ND	6	8
Copper	60	50	60	50	60	63	61	47
*Hexavalent Chromium	NT	NT	NT	NT	NT	NT	NT	NT
Lead	8	8	10	11	6	14	10	12
Mercury	ND	ND	ND	0.4	ND	ND	<0.3	<0.3
Molybdenum	NT	NT	NT	NT	2.5/2.3	ND	2.1/2.1	<5
Nickel	6	ND	ND	ND	50	30	<20	20
Selenium	ND	ND	ND	ND	ND	ND	<2	<1
Silver	9.9	10.1	14.7	13.4	14.0	12.8	10.6	7.9
Thallium	ND	ND	ND/ND	ND	ND/ND	ND	0.6/0.6	<0.5
Zinc	98	59	101	78	81	88	79	75
PESTICIDES ($\mu\text{g/L}$)								
gamma-BHC (lindane)	ND	ND	0.12	ND	ND	ND	ND	ND
alpha-Chlordane	ND	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	ND	ND	ND	ND	ND
*2,4'-DDT	ND	ND	NT	NT	NT	NT	NT	NT
4,4'-DDT	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan Sulfate	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND	ND
OTHER								
Cyanide ($\mu\text{g/L}$)	ND	ND	6	6	20	10	40	20
Asbestos (million fibers/L) ^f	34	22	28.5	ND	ND	ND	1.500	4.900

Table 21. Comparison of Toxic Pollutants and Pesticides in Anchorage's Final Effluent over the Last Ten Years. (continued) Values in brackets are from EPA Method 602.

Pollutant	1996		1997		1998	
	Wet ^d 8/6-7	Dry ^d 8/16-17	Dry ^d 6/30-7/1	Wet ^d 8/19-20	Dry 6/18-19	Wet 8/11-12
METALS ($\mu\text{g/L}$)						
Antimony	<10	<10/<10	ND	ND/ND	ND	ND
Arsenic	4	3	2	3	3	13
Beryllium	<0.1	<0.1	ND	ND	ND	ND
Cadmium	<4	4	ND	ND	ND	ND
Chromium	5	8	ND	ND	ND	ND
Copper	67	47	56	53	60	49
*Hexavalent Chromium	NT	NT	NT	NT	NT	NT
Lead	5	5	12	19	3	8
Mercury	<0.3	<0.3	ND	ND	0.1	ND
Molybdenum	2.6	ND/ND	ND	ND/ND	ND	ND
Nickel	20	20	ND	30	10	40
Selenium	<2, <10 ^e	<2, <10	ND,ND	ND,ND,ND	ND	ND
Silver	8.6	8.2	8.8	8.2	5.7	11.3
Thallium	<10	<10/<10	ND	ND,ND	ND	ND
Zinc	77	74	40	73	65	79
PESTICIDES ($\mu\text{g/L}$)						
gamma-BHC (lindane)	0.94/ND	.12	ND	ND	ND	ND
alpha-Chlordane	ND	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	ND	ND	ND
*2,4'-DDT	NT	NT	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND	ND
Endosulfan Sulfate	ND	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND
OTHER						
Cyanide ($\mu\text{g/L}$)	30	20	20	20	ND	ND
Asbestos (million fibers/L) ^f	ND	ND	ND	ND	ND	ND

* Non-priority pollutants

^a Analyzed using method SM 503B (1986-1995; 1997; 1998); method EPA 1664 HEM in 1996

^b Analyzed using method SM 503E (1986-1995; 1997; 1998); method EPA 1664 SGT-HEM in 1996

^c Analyzed using EPA Method 625

^d Duplicate effluent collected (value/duplicate value)

^e Values from EPA Method 624 are the result of averaging eight samples with zero used for ND

^f Conversion from ppm to millions of fibers per liter dependent on fiber size

^g Selenium tested by two laboratories (AWWU value, ToxScan value)

^h Acetone was classified as a Tentatively Identified Compound in 1996

ND Not detected

NT Not tested

Historic influent and effluent metals and cyanide concentrations collected as part of AWWU's self-monitoring program are presented in Table 22. With few exceptions, concentrations are fairly consistent over time. All metals and cyanide in the influent and effluent during 1998 were found to fall within the typical range of concentrations seen during prior years.

Arsenic concentrations in the final effluent have remained fairly steady. The highest monthly maximum for the final effluent during the reporting period was $26\text{ }\mu\text{g/L}$, compared to an MAEC of $12,700\text{ }\mu\text{g/L}$ (Table 18). Arsenic concentrations in the sludge had been elevated during 1992-1994, the last four years have shown decreased average arsenic levels ranging from 9.4 to 18.1 mg/kg (Table 23). The apparent increase of arsenic in sludge in 1998 was due to one anomalously high concentration (257.0 mg/kg) seen on 10 July 1998; this high concentration of arsenic as well as some metals were correlated with the influent and effluent concentrations, as has been seen in the past. Arsenic values are not a serious concern for this Permit in terms of effluent concentrations, since the concentration in the final effluent is so much lower than the MAEC. Although proposed arsenic criteria for Permit renewal are substantially lower than those utilized in the current Permit, arsenic in plant effluent will likely remain well below the MAEC.

During the first year of monitoring, total cyanide concentration in the effluent exceeded the MAEC of $50\text{ }\mu\text{g/L}$ a number of times. During the second year of sampling, the highest monthly average cyanide concentration measured in the effluent was $39\text{ }\mu\text{g/L}$, and during the next seven years (through 1994), the highest monthly values were always less than $32\text{ }\mu\text{g/L}$, below the MAEC. The maximum cyanide concentrations in effluent ranged from $40 - 50\text{ }\mu\text{g/L}$ in 1995 through 1997, with the 1996 maximum equaling the MAEC at $50\text{ }\mu\text{g/L}$. The maximum in 1998 has decreased to 20, and the average total cyanide was calculated at $15\text{ }\mu\text{g/L}$, a decrease from the averages reported over the last three years ($21 - 29\text{ }\mu\text{g/L}$). It was observed (in 1986) that the effluent cyanide concentrations often exceeded the influent concentrations by an order of magnitude. This trend continued during subsequent years of sampling and was the subject of a special investigation conducted by the AWWU. The conclusion of this investigation was that the measured increase in cyanide between the influent and effluent is the result of the treatment plant's incinerator. Cyanide formed in the incinerator during sludge incineration is returned to the plant during the stack scrubbing process (CH2M Hill, 1987; CH2M Hill in association with Loren Leman, P.E., 1988). The decrease in cyanide concentrations in years two through seven of sampling is believed to be due to the change in the scrubbing water source from recirculated primary effluent to well water. Analysis of total cyanide and free cyanide (cyanide amenable to chlorination) was performed in 1990 that indicated that the amount of cyanide in the final effluent is slightly reduced due to the chlorination process (KLI, 1991). Total cyanide measured on both the final effluent and prior to chlorination had similar concentrations, with the amount of cyanide amenable to chlorination (free cyanide) only $0 - 1\text{ }\mu\text{g/L}$ less than the concentration of total cyanide.

Copper concentrations in both the influent and effluent correspond well with data from previous years (Table 22). The slight decrease in sludge concentrations seen during 1993 - 1997 continued into 1998 (Table 23). The exact cause of this decrease has not been determined, however, the lower values correspond with the changes in the drinking water supply described earlier.

Historic discharge monitoring data for other parameters of concern measured in the influent and effluent are presented in Table 24. Most parameters have remained fairly steady over time. Dissolved oxygen levels had been steadily increasing since 1986 but showed a peak in 1992, with

Table 22. Historical Discharge Monitoring Data for Influent and Effluent Heavy Metals, Arsenic, and Cyanide. Concentrations are in $\mu\text{g/L}$. Values represent yearly average (Avg) or monthly minimum (Min) and maximum (Max) for each year (Nov. - Oct.).

Year	Flow (MGD)	Arsenic		Beryllium		Cadmium		Copper		Lead		Mercury	
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1986 Avg	28	3	2	NT	NT	7	10	102	85	21	12	0.55	0.45
1986 Min	23	<1	<1	NT	NT	5	5	80	60	10	6	0.3	0.2
1986 Max	29	4	4	NT	NT	12	29	120	120	68	33	1	0.7
1987 Avg	25	3	3	NT	NT	9	10	123	100	21	16	0.8	0.6
1987 Min	24	<1	<1	NT	NT	<5	5	70	70	<1	<1	<0.2	<0.2
1987 Max	28	5	5	NT	NT	20	30	210	150	60	50	2.6	1.5
1988 Avg	27	2	<2	NT	NT	6	<5	163	109	19	13	<0.4	<0.3
1988 Min	23	1	<1	NT	NT	5	5	100	60	12	6	<0.2	<0.2
1988 Max	34	4	8	NT	NT	11	7	280	150	26	19	0.7	0.5
1989 Avg	31	3	3	NT	NT	7	6	104	87	16	12	0.4	0.4
1989 Min	27	<1	<1	NT	NT	<5	<5	80	60	9	5	<0.2	0.2
1989 Max	36	4	4	NT	NT	13	12	160	120	28	22	0.4	0.6
1990 Avg	33	3	3	NT	NT	6	6	94	74	15	9	0.6	0.5
1990 Min	27	2	2	NT	NT	<5	5	70	60	7	5	0.4	0.4
1990 Max	39	5	5	NT	NT	9	10	130	110	28	26	1.1	0.6
1991 Avg	33	3	3	NT	NT	4	4	102	70	17	10	0.7	0.3
1991 Min	30	<1	<1	NT	NT	0.6	0.6	80	60	11	6	<0.3	<0.3
1991 Max	37	8	8	NT	NT	5	6	140	100	35	16	3.0	0.5
1992 Avg	31	7	4	NT	NT	6	6	81	45	21	9	0.4	0.3
1992 Min	29	2	2	NT	NT	<0.5	<0.5	36	38	9	4	<0.3	<0.3
1992 Max	36	18	12	NT	NT	15	16	110	54	35	19	0.8	0.5
1993 Avg	30	7	5	<0.1	<0.1	6	6	96	54	21	10	0.5	0.4
1993 Min	28	<2	2	<0.1	<0.1	<5	<5	80	40	12	3	<0.3	<0.3
1993 Max	34	26	13	0.1	0.1	12	9	120	80	38	21	1.1	0.6
1994 Avg	30	5	5	<0.1	<0.1	6	5	90	54	19	9	0.4	<0.3
1994 Min	28	2	2	<0.1	<0.1	<5	<5	60	38	4	5	<0.3	<0.3
1994 Max	35	21	16	0.1	<0.1	9	6	110	90	30	14	0.8	0.3
1995 Avg	30	4	3	<0.1	<0.1	<5	<5	84	49	25	9	0.3	<0.3
1995 Min	27	<1	<1	<0.1	<0.1	<5	<5	60	39	3	<1	<0.3	<0.3
1995 Max	36	7	7	0.1	<0.1	5	8	105	64	76	43	0.7	0.4
1996 Avg	30	3	2	<0.1	<0.1	5	4	91	51	12	7	0.4	<0.3
1996 Min	28	<1	<1	<0.1	<0.1	<4	<4	78	41	<1	<1	<0.3	<0.3
1996 Max	33	7	5	0.1	0.1	8	7	114	63	21	17	0.7	<0.3
1997 Avg	34	3	2	<0.1	<0.1	5	5	93	50	20	7	0.4	<0.2
1997 Min	29	1	<1	<0.1	<0.1	<4	<4	63	10	10	4	<0.2	<0.2
1997 Max	40	5	4	0.3	0.2	7	5	123	64	59	11	0.8	0.2
1998 Avg	28.6	4	3	0.1	0.1	5	5	74	41	12	6	0.3	0.2
1998 Min	26.6	<2	<2	<0.1	<0.1	<5	<5	60	30	4	<1	<0.2	<0.1
1998 Max	30.7	13	15	0.1	0.1	6	6	90	60	26	21	0.5	<0.2

Table 22. Historical Discharge Monitoring Data for Influent and Effluent Heavy Metals, Arsenic, and Cyanide. (continued) Concentrations are in $\mu\text{g/L}$. Values represent yearly average (Avg) or monthly minimum (Min) and Maximum (Max) for each year (Nov. - Oct.).

Year	Nickel		Silver		Zinc		Chromium (Total)		Cyanide (Total)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1986 Avg	42	44	19	15	144	131	50	50	28	33
1986 Min	40	40	10	10	110	60	50	50	20	19
1986 Max	60	60	40	40	230	240	50	50	85	47
1987 Avg	40	43	17	11	151	106	<50	<50	3	17
1987 Min	<40	<40	<10	<10	80	70	<50	<50	1	3
1987 Max	40	60	30	20	260	136	<50	<50	5	39
1988 Avg	40	42	10	13	153	98	<50	<50	2	10
1988 Min	<4	<4	3	1	104	56	<50	<50	1	1
1988 Max	<40	50	18	46	228	129	<50	<50	17	22
1989 Avg	17	16	10.2	16	109	86	<34	<34	3	19
1989 Min	2	<2	6.3	4.4	82	56	<1	<1	1	6
1989 Max	17	10	12	98	136	134	<50	<50	3	26
1990 Avg	20	14	10	7	112	82	45	46	4	17
1990 Min	<1	<1	3	4	86	64	<30	<30	<4	4
1990 Max	60	10	14	10	146	145	13	21	6	32
1991 Avg	10	10	11	8	126	77	21	26	4	7
1991 Min	3	3	4.2	2.7	90	62	<1	<1	<4	4
1991 Max	<20	30	18.9	12.3	161	120	<30	<30	4	12
1992 Avg	18	10	11.7	7.9	133	67	24	32	<6	6
1992 Min	3	2	2.9	0.9	54	41	5	7	<0.4	<4
1992 Max	30	40	16.9	12.3	177	88	40	120	<28	8
1993 Avg	27	26	12	8	137	71	17	21	4	8
1993 Min	8	3	5	3	98	41	4	11	<4	<4
1993 Max	40	30	25.2	14.7	200	101	<30	33	<7	26
1994 Avg	20	22	13	7	134	73	13	19	<8	14
1994 Min	<10	<10	8.6	4.9	70	50	6	<10	<4	<6
1994 Max	30	40	24.1	12.8	183	150	<20	30	<10	24
1995 Avg	<20	<20	10.4	6.6	145	70	6	14	<10	26
1995 Min	<20	<20	1.8	2.0	93	58	<5	<5	<10	20
1995 Max	50	40	17.2	12.6	183	87	11	52	<10	40
1996 Avg	21	22	10.2	6.6	153	69	19	24	10	29
1996 Min	<20	<20	4.1	3.1	124	56	<4	10	<10	20
1996 Max	30	30	17.0	12.4	201	80	112	98	10	50
1997 Avg	24	23	9.4	6.4	140	64	7	12	<10	21
1997 Min	<20	<20	3.4	2.2	91	38	<4	<5	<10	<10
1997 Max	40	40	17.5	10.0	186	97	13	23	<10	40
1998 Avg	26	22	11.1	6.8	136	64	8	10	15	15
1998 Min	<20	<20	4.4	3.0	104	53	<5	<5	<10	<10
1998 Max	77	40	16.1	11.1	182	88	10	16	<40	20

NT Not Tested

Table 23. Historical Discharge Monitoring Data for Sludge Heavy Metals, Arsenic, and Cyanide. Concentrations are in mg/kg dry weight. Values represent yearly average (Avg) or monthly minimum (Min) and maximum (Max) for each year (Nov. - Oct.)

Year	Arsenic	Beryllium	Cadmium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Chromium (Total)	Cyanide (Total)
1986 Avg	5.6	NT	4.4	300	75	1.6	22	37	560	21	3.44
1986 Min	2.2	NT	2.0	252	40	0.54	<8	6.4	121	3.38	1.63
1986 Max	14.2	NT	10.0	405	115	2.90	42	57	712	30	5.18
1987 Avg	3.5	NT	4.0	309	100	1.7	23	33	574	20	1.1
1987 Min	2.7	NT	1.6	190	36	0.2	10	19	413	12	0.4
1987 Max	5.2	NT	5.9	445	170	3.0	40	56	790	27	1.9
1988 Avg	3.5	NT	4.4	384	181	1.7	24	57	642	22	1.5
1988 Min	1.7	NT	1.2	241	36	<0.1	15	37	439	7	<1.0
1988 Max	4.8	NT	8.7	496	940	6.2	39	110	806	34	3.0
1989 Avg	3.8	NT	3.8	344	105	1.9	19	34	547	26	1.1
1989 Min	1.8	NT	2.3	290	68	0.8	11	8	384	20	0.58
1989 Max	6.0	NT	5.0	411	160	3.2	28	50	660	36	3.78
1990 Avg	6.8	NT	4.2	360	92	2.4	22	35	588	28	0.45
1990 Min	2.4	NT	2.2	206	53	1.2	8.2	20.5	345	20	<0.15
1990 Max	17.4	NT	6.6	532	136	3.8	35	50	920	34	0.73
1991 Avg	6.0	NT	4.2	316	87	3.0	20	32	567	24	0.52
1991 Min	3.7	NT	2.8	248	54	1.2	13	22.4	398	13.4	0.36
1991 Max	10.3	NT	6.3	388	132	7.3	27	43	747	34	0.71
1992 Avg	39.4	NT	4.4	293	167	2.1	20	35.1	585	25	0.7
1992 Min	1.7	NT	3.2	236	80	1.0	13	7.6	476	19	0.066
1992 Max	151	NT	5.2	335	468	3.4	25	44.4	702	31	1.42
1993 Avg	29.9	0.15	4.3	294	99	2.4	21	40.3	564	24.9	0.622
1993 Min	5.5	0.10	2.5	210	64	0.86	13	14	390	14	0.182
1993 Max	101	0.20	5.6	398	171	5.8	26.5	94.6	821	37	0.926
1994 Avg	23	0.10	4.0	278	73	1.5	19	34	554	22	1.14
1994 Min	6.6	0.05	2.6	224	54	0.8	15	14.6	476	11	0.369
1994 Max	134	0.20	8.2	338	114	2.5	24	52.4	656	29	1.72
1995 Avg	14.6	0.11	4.4	265	124	1.4	19	29.2	554	24	1.35
1995 Min	3.4	<0.02	2.6	221	45	0.7	13	18.7	438	16	0.9
1995 Max	50	0.20	9.8	314	324	1.9	28	41.4	738	38	2.0
1996 Avg	11.2	0.12	3.6	249	62	1.7	18	25.4	548	27	1.79
1996 Min	5.2	0.07	2.4	189	49	0.8	15	3.6	395	20	1.14
1996 Max	31.7	0.22	4.7	308	104	3.3	26	65.4	723	48	2.19
1997 Avg	9.4	0.11	3.7	268	60	1.4	22	23.8	547	21	1.43
1997 Min	5.0	<0.02	1.4	197	32	0.2	14	3.4	415	13	0.84
1997 Max	20.4	0.19	5.1	385	80	2.8	27	44.7	756	26	1.99
1998 Avg	18.0	0.10	3.0	229	70	1.5	18	26.4	485	20	1.73
1998 Min	3.6	0.07	0.7	176	33	0.7	11	7.2	392	5	0.58
1998 Max	135.8	0.14	5.2	276	294	2.9	26	80.5	655	55	<3.0

NT Not tested

Table 24. Historical Discharge Monitoring Data for Influent and Effluent Non-Metals, 1988 - 1998. Values represent yearly average (Avg) or monthly minimum (Min) and maximum (Max) for each year (Nov. - Oct.).

Year	Temperature (°C)		pH ^a		Total Residual Chlorine (mg/L)		DO (mg/L)		BOD ₅ (mg/L)		Settleable Solids (mL/L)		Total Susp. Solids (mg/L)		Fecal Coliform (FC/100 mL)		Oil and Grease (mg/L)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
1988 Avg	12	12	6.9-7.6	6.8-7.5	NA	0.8	NA	5.0	170	111	6.5	<0.1	187	62	NA	77	NA	18.0
1988 Min	11	10	NA	NA	NA	0.8	NA	4.3	141	90	5.4	<0.1	136	49	NA	17	NA	12.2
1988 Max	15	15	NA	NA	NA	0.9	NA	5.5	203	124	7.6	0.2	238	74	NA	226	NA	27.4
1989 Avg	12	12	6.9-7.5	6.8-7.4	NA	0.9	NA	5.7	141	102	5.6	<0.1	143	60	NA	51	NA	20.8
1989 Min	10	9	NA	NA	NA	0.8	NA	4.5	98	69	3.5	<0.1	131	43	NA	5	NA	14.0
1989 Max	14	15	NA	NA	NA	1.0	NA	6.6	173	122	6.9	<0.1	183	86	NA	197	NA	30.1
1990 Avg	12	12	6.6-7.6	6.5-7.5	NA	0.8	NA	5.9	129	91	4.3	0.2	140	52	NA	44	NA	20.7
1990 Min	9	9	NA	NA	NA	0.6	NA	4.8	96	71	3.1	<0.1	117	40	NA	6	NA	8.2
1990 Max	16	16	NA	NA	NA	0.9	NA	6.8	153	107	5.7	<0.4	184	65	NA	166	NA	27.3
1991 Avg	11	11	6.8-7.7	6.7-8.5	NA	0.8	NA	6.8	185	92	5.3	<0.1	198	47	NA	44	NA	20.7
1991 Min	9	9	NA	NA	NA	0.7	NA	6.3	141	77	4.3	<0.1	118	39	NA	7	NA	12.8
1991 Max	15	15	NA	NA	NA	0.9	NA	7.5	235	106	6.9	<0.1	246	53	NA	128	NA	24.8
1992 Avg	12	12	6.8-7.7	6.8-7.5	NA	0.8	NA	7.5	211	101	6.2	<0.1	229	51	NA	101	NA	21.1
1992 Min	10	10	NA	NA	NA	0.7	NA	6.4	165	79	5.2	<0.1	188	46	NA	36	NA	14.5
1992 Max	15	16	NA	NA	NA	0.8	NA	8.6	254	126	8.2	<0.1	268	60	NA	243	NA	26.3
1993 Avg	13	13	6.4-7.8	6.4-7.5	NA	0.8	NA	6.8	226	103	6.8	0.1	239	49	NA	84	NA	21.4
1993 Min	11	11	NA	NA	NA	0.8	NA	5.8	211	95	5.4	<0.1	207	44	NA	14	NA	18.0
1993 Max	16	16	NA	NA	NA	1.0	NA	7.9	245	110	8.0	0.3	277	53	NA	330	NA	25.0
1994 Avg	13	13	6.8-7.8	6.5-7.8	NA	0.9	NA	6.8	244	111	7.6	<0.2	250	48	NA	31	NA	23.2
1994 Min	10	10	NA	NA	NA	0.7	NA	4.8	204	91	6.3	<0.1	214	44	NA	7	NA	19.6
1994 Max	17	17	NA	NA	NA	0.9	NA	8.2	294	130	9.1	<0.4	286	55	NA	114	NA	26.1
1995 Avg	13	13	6.7-8.0	6.3-7.7	NA	0.8	NA	6.7	253	110	7.5	<0.1	247	49	NA	38	NA	23.3
1995 Min	10	10	NA	NA	NA	0.7	NA	6.0	200	87	6.7	<0.1	194	45	NA	19	NA	13.1
1995 Max	16	16	NA	NA	NA	0.9	NA	7.3	296	129	8.2	<0.1	275	56	NA	79	NA	27.1
1996 Avg	12	13	7.0-7.7	6.9-7.5	NA	0.8	NA	6.6	242	106	7.7	<0.1	245	49	NA	31	NA	24.2
1996 Min	10	10	NA	NA	NA	0.7	NA	6.1	206	86	6.6	<0.1	214	44	NA	8	NA	22.0
1996 Max	15	16	NA	NA	NA	0.9	NA	7.8	262	117	8.3	<0.1	282	54	NA	106	NA	26.5
1997 Avg	12	13	7.0-7.7	6.9-7.5	NA	0.9	NA	6.3	243	111	6.8	<0.1	260	48	NA	60	NA	24.8
1997 Min	10	10	NA	7.5	NA	0.8	NA	5.8	225	99	5.8	<0.1	228	43	NA	19	NA	21.3
1997 Max	16	16	NA	7.9	NA	0.9	NA	7.0	277	132	8.0	<0.1	307	53	NA	179	NA	26.9
1998 Avg	12	13	6.4-7.9	6.5-7.9	NA	0.8	NA	6.2	236	108	6.4	<0.1	251	50	NA	23	NA	24.1
1998 Min	10	11	NA	NA	NA	0.8	NA	5.6	184	91	5.8	<0.1	204	44	NA	12	NA	13.5
1998 Max	15	15	NA	NA	NA	0.9	NA	6.7	272	121	7.6	<0.1	292	55	NA	44	NA	28.1

^a Values represent yearly pH minimum and maximum
NA Not applicable

decreased levels over most of the last six years (Table 23). The cause of the changes in DO levels is unknown, however, previous changes in sampling location could account for some of the past increase. Other constituents of concern such as TSS have remained fairly steady in the effluent; influent TSS levels had increased during 1991 due to improved sampling methodology but have remained fairly steady since that time. The BOD₅ effluent average during 1998 (108 mg/L) was similar to the range of 106 to 111 mg/L seen during the prior four years. However, BOD₅ levels in both the influent and effluent have shown a slight upward trend as a result of greater industrial contributors (e.g., fish processors) over the course of the program. The yearly average effluent fecal coliform bacteria concentration reported at 23 FC/100 mL for 1998 was the lowest to date seen on the program. The maximum monthly average reported this year was also the lowest seen (44 FC/100 mL) over the course of the program.

5.2 WATER QUALITY MONITORING

5.2.1 Plume Dispersion Sampling

Hypothesis Testing

To test the hypothesis that the water quality at the ZID boundary was not degraded with respect to the water quality at the nearfield and control stations, the non-parametric Kruskal-Wallis Test (Zar, 1984) was employed which determined whether significant differences occurred within the sample group. If significant differences were observed, Dunn's test, a test that performs pair-wise tests of significance ($\alpha = 0.05$), was employed (Dunn, 1964). The results of these tests for the August survey period as a function of water quality parameters are presented in Table 25. Non-detect values were replaced with the detection limit value for statistical testing. In the case of UCM, where no detection limit was applicable, a value of 10 $\mu\text{g/L}$ was used to replace values of 0.0 ng/L.

Data from the receiving water survey showed no statistically significant difference between outfall and control stations for temperature, salinity, DO, and turbidity at surface, mid-, and bottom sampling depths. Historically, the salinities at the control stations have been lower than those at the outfall stations due to the control stations being located closer to sources of freshwater input. In addition, the temperatures at the control stations have historically been lower than those at the outfall, most likely due to the influence of colder freshwater inputs near the control stations.

Statistical analyses indicated significant differences between station groups at mid- and bottom depths for pH. Review of the data show that the pH at the control stations at these depths were slightly higher than those at the outfall stations. However, the range of pH values at all stations was small (approximately 0.5 pH units), so this parameter is not of concern in terms of the discharge from Point Woronzof. It is likely that, as in the past, small differences in pH can be attributed to the natural variability in the two water masses being sampled, even though these differences were not apparent this year in salinity or temperature.

A statistically significant difference in color was noted between the ZID boundary station and the control stations, probably due in part to the one high value seen at Station 1F2-2SB (25 color units). Differences in color values have not typically been seen in the past and are not judged this year to be of particular concern. Due to the high turbidity in the receiving water, differences in color are

Table 25. Significant Station Pairs at the 5% Significance Level Using the Kruskal-Wallis and Dunn's Tests.

Parameter	Sample Depth		
	Surface	Middle	Bottom
Temperature	NS	NS	NS
Salinity	NS	NS	NS
Dissolved Oxygen	NS	NS	NS
pH	NS	1,4 / 2,4*	1,4 / 2,4 / 3,4*
Turbidity	NS	NS	NS
Color Units	2,4*	----	----
Fecal Coliform ^{SMZ}	A,C / B,C*	----	----
Enterococci Bacteria ^{SMZ}	A,C / B,C*	----	----
Residual Chlorine ^{SMZ}	A,C*	----	----
Antimony**	NS ^D ,NS ^{TR}	----	----
Arsenic**	SIG ^D ,NS ^{TR}	----	----
Beryllium**	NS ^D ,NS ^{TR}	----	----
Cadmium**	NS ^D ,NS ^{TR}	----	----
Chromium**	NS ^D ,NS ^{TR}	----	----
Copper**	SIG ^D ,NS ^{TR}	----	----
Mercury**	NS ^D ,NS ^{TR}	----	----
Nickel**	SIG ^D ,NS ^{TR}	----	----
Lead**	SIG ^D ,NS ^{TR}	----	----
Selenium**	NS ^D ,NS ^{TR}	----	----
Silver**	NS ^D ,NS ^{TR}	----	----
Thallium**	NS ^D ,NS ^{TR}	----	----
Zinc**	NS ^D ,NS ^{TR}	----	----
Cyanide**	NS	----	----
Total Suspended Solids**	NS	----	----
Total Aromatic Hydrocarbons (EPA 602)**	NS	----	----
Polynuclear Aromatic Hydrocarbons (GC/MS)	NS	----	----
Cholesterol**	SIG	----	----
Coprostanol**	SIG	----	----
Total Aliphatic Hydrocarbons (GC FID)**	NS	----	----
Unresolved Complex Mixture (GC FID)**	NS	----	----

* Group 1: Within ZID Stations
 Group 2: ZID Boundary Stations
 Group 3: Nearfield Stations
 Group 4: Control Stations
 Group A: Mixing Zone Stations (1+2)
 Group B: Nearfield Stations (3)
 Group C: Control Stations

** Statistics performed on stations along Drogue F1 versus the control, Drogue C1.
 ---- Not Applicable (surface samples only)
 NS Not Significant
 SIG Significant
^D Dissolved
^{TR} Total Recoverable
^{SMZ} Statistics performed on State of Alaska definition of Mixing Zone (Group 1+2)

most likely associated with the effective removal of this interference. The other outfall stations (within ZID and nearfield) did not exhibit differences when compared to the control stations.

Enterococci, fecal coliform, and TRC results were grouped based on the larger State of Alaska definition of the mixing zone (including the within ZID and ZID boundary stations) for statistical comparisons. All three of these parameters showed some significant differences between mixing zone and control stations.

Enterococci results showed significant differences between the mixing zone and nearfield stations as compared to the control stations, with higher levels seen at the stations near the outfall. Enterococci values ranged from 2.0 to 20.6 MPN/100 mL at the stations near the outfall and from <1.0 to 4.1 MPN/100 mL at the control stations. Fecal coliform concentrations were also significantly higher in the mixing zone station group and the nearfield station group as compared to the control. Fecal coliform concentrations values ranged from 2.2 to >1,600 FC/100 mL at the outfall stations compared to range of <2.2 to 9.2 FC/100 mL at the control stations. Increased values seen at the outfall stations may be influenced by the Point Woronzof discharge; however, it is important to note that high bacterial concentrations (both enterococci and fecal coliform) were seen in area creeks which enter Knik Arm. This is supported by the fact that the nearfield station values were also significantly higher than that seen at the controls for both enterococci, and fecal coliform. Also, fecal concentrations in the effluent were relatively low, with 1998 having the lowest monthly averages and maximum compared to the last 10 years (Table 24).

The TRC values were higher at the mixing zone stations than at the control, which only showed one value above the detection limit (Station 1C3-2SR). Detectable TRC was found at two mixing zone stations on the ebb tide (Stations 1E2-2SB and 1E3-1SW) and four mixing zone stations on the flood tide (1F1-1SW, 1F1-2SB, 1F2-1SW, and 1F3-2SB). Differences in TRC concentrations between mixing zone (within ZID and ZID boundary) and control stations are likely attributed to the discharge. Nearfield stations were not shown to be significantly different from the control stations. With the exception of one nearfield station (1E3-3SN), no detectable TRC was seen at any of the outfall stations outside the mixing zone specified by the State of Alaska.

In addition to the standard water quality sampling, concentrations of total aromatic hydrocarbons, PAH, aliphatic hydrocarbons, UCM, cholesterol, and coprostanol were measured at the surface at six stations (three at the flood tide control site and three at the flood tide outfall site). No significant differences were found between the control and outfall station groups for any of the hydrocarbon measurements except for coprostanol and cholesterol, which were significantly elevated in the outfall stations over the control, indicating the presence of human wastes in this vicinity.

Total suspended solids and total recoverable and dissolved metals samples collected at the outfall and control sites were also subject to statistical testing. No significant differences between locations were noted for TSS. None of the total recoverable metals concentrations were found to be significantly different between locations. Dissolved arsenic, copper, nickel, and lead showed significant differences between the outfall and control locations. All four of these dissolved metals were found to be elevated at the outfall sites with respect to control. Concentrations of copper,

nickel, and lead were quite high at Station 1F1-1SW as compared to the other two outfall stations, but the reported concentrations of all of these metals were well below their respective receiving water quality standards. The other dissolved metals concentrations were comparable between locations.

Concentrations of all but three of the metals were significantly lower than allowable receiving water quality criteria established by EPA (Table 18). These metals were total recoverable copper, mercury, and nickel. With the exception of mercury, all of these concentrations exceeded the receiving water standards for all six stations (three outfall and two control). Total recoverable mercury exceeded the water quality standard at all stations except the nearfield outfall station (1F1-3SN). Dissolved metals were all below allowable receiving water quality criteria.

Comparison with Water Quality Criteria and Permit Limits

Receiving waters of Knik Arm are not classified for a specific water use under the State of Alaska Water Quality Standard Regulations. Therefore, regulations provide that the most restrictive use criteria must apply. State marine water quality criteria (18 AAC 70.020) for contact recreation require that the mean fecal coliform concentration calculated from a minimum population of five samples taken within a 30-day period not exceed 20 FC/100 mL and that not more than ten percent of the samples exceed 40 FC/100 mL. State marine water quality criteria for secondary recreation require that the mean fecal coliform concentration not exceed 200 FC/100 mL and that not more than ten percent of the samples exceed 400 FC/100 mL. State marine water quality criteria for the harvesting for consumption of raw mollusks and other raw aquatic life require that, based on a 5-tube decimal dilution test, the median shall not exceed 14 FC/100 mL and that not more than ten percent of the samples shall exceed 40 FC/100 mL. Since contact recreation (swimming, etc.) is not performed in these waters and there are virtually no shellfish in this region of the Cook Inlet/Knik Arm, it seems that the criteria for secondary recreation is most applicable; however, these criteria are not the most restrictive. Therefore, the most restrictive criteria used were that the median shall not exceed 14 FC/100 mL (consumption of raw shellfish and other aquatic life) and that not more than ten percent shall exceed 40 FC/100 mL (contact recreation) (Table 26).

Fecal coliform concentrations were found to be significantly different between control versus within ZID station groups (Table 25). The median value reported for fecal coliform during receiving water sampling was 9.2 FC/100 mL, below the criterion of 14 FC/100 mL (Table 12). The criterion of not more than 10 percent of the samples exceeding 40 FC/100 mL could not strictly be assessed due to the fact that many fecal values were reported as >16.0 FC/100 mL. This included some nearfield values that are quite removed from the outfall area itself. As in the past, the highest concentrations of fecal coliform and enterococci bacteria were reported in area creeks rather than the receiving water (Table 15). Values of 23.0, 30.0, and 300 FC/100 mL were reported for Chester, Ship, and Fish Creek, respectively.

A comparison of the water quality data listed in Table 12 with the marine receiving water quality for the State of Alaska (Tables 18 and 26) indicates that with the exception of turbidity and color, none of the parameters listed in Table 12 exceeded the State's standards. Due to the high natural suspended sediment concentrations in Cook Inlet, turbidity exceeded the State's water quality criteria

Table 26. State of Alaska Water Quality Standards for Receiving Water.

Parameter	Most Restrictive Marine Water Quality Standards								
Fecal Coliform	Based on a 5-tube decimal dilution test the fecal coliform median MPN shall not exceed 14 FC/100 ml (harvesting for consumption of raw shellfish), and not more than ten percent (10%) of the samples shall exceed 40 FC/100 ml (contact recreation).								
Dissolved Oxygen	Dissolved oxygen concentrations in estuaries and tidal tributaries shall not be less than 5.0 mg/L except where natural conditions cause this value to be depressed.								
pH	pH shall not be less than 6.5 or greater than 8.5, and shall not vary more than 0.5 pH unit from natural condition.								
Turbidity	Turbidity shall not exceed 25 NTU.								
Temperature	Temperature shall not cause the weekly average temperature to increase more than 1° C. The maximum rate of change shall not exceed 0.5° C per hour. Normal daily temperature cycles shall not be altered in amplitude or frequency.								
Salinity	Maximum allowable variation above natural salinity: <table> <tr> <th>Natural Salinity (‰)</th><th>Man-induced Salinity (‰)</th></tr> <tr> <td>0 to 3.5</td><td>1</td></tr> <tr> <td>3.5 to 13.5</td><td>2</td></tr> <tr> <td>13.5 to 35</td><td>4</td></tr> </table>	Natural Salinity (‰)	Man-induced Salinity (‰)	0 to 3.5	1	3.5 to 13.5	2	13.5 to 35	4
Natural Salinity (‰)	Man-induced Salinity (‰)								
0 to 3.5	1								
3.5 to 13.5	2								
13.5 to 35	4								
Sediment	No measurable increase in concentrations above natural conditions.								
Color	Color shall not exceed 15 color units.								
Petroleum Hydrocarbons, Oils and Grease	Total hydrocarbons in the water column shall not exceed 15 µg/L. Total aromatic hydrocarbons in the water column shall not exceed 10 µg/L. Shall not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters shall be virtually free from floating oils.								
Total Residual Chlorine	Concentrations shall not exceed 2.0 µg/L for salmonoid fish or 10.0 µg/L for other organisms.								
Toxic and Other Deleterious Substances	See Table 18.								

of 25 NTUs at all stations and at all depths. The color criterion of a maximum 15 color units was exceeded once during the receiving water sampling, at the ZID boundary at Station 1F2-SB. All other color values reported for the program were below 15 color units.

The State's receiving water quality standard for the "growth and propagation of fish, shellfish, aquatic life, and wildlife including seabirds, waterfowl, and furbearers" is 15 $\mu\text{g/L}$ for total hydrocarbons and 10 $\mu\text{g/L}$ for total aromatic hydrocarbons. Total hydrocarbons as oil and grease (SM 503B) and total petroleum hydrocarbon (SM 503E) were not analyzed during recent years of the program (1995 - 1998) due to the fact that the detection limit of these methods (50-100 $\mu\text{g/L}$) are above the State-specified limits (15 $\mu\text{g/L}$). The limited usefulness of these methods has been recognized by the newly-revised State of Alaska water quality regulations that were issued in March 1996, as discussed in Section 5.1. Instead, total petroleum hydrocarbons (aliphatics) were measured using GC/FID techniques, and total PAH were measured using GC/MS SIM. In addition, total aromatic hydrocarbons were measured as BETX using EPA Method 602. The new State regulations define total aromatic hydrocarbons (TAH) as BETX, with a limit of 10 $\mu\text{g/L}$; and total aqueous hydrocarbons (TAqH) is defined as the sum of TAHs plus total PAHs from EPA Method 610, with a limit of 15 $\mu\text{g/L}$.

The maximum level of total petroleum hydrocarbons (aliphatics) measured by GC/FID was 12.6 $\mu\text{g/L}$, below the 15 $\mu\text{g/L}$ limit. Total aromatic hydrocarbons as BETX as measured by EPA Method 602 were below detection limits at all but one station (1C1-2SR). The BETX at this station was 4.4 $\mu\text{g/L}$, approximately half of the State-specified water quality standard of 10 $\mu\text{g/L}$. Total PAH concentrations determined by GC/MS SIM ranged from approximately 0.05 to 0.3 $\mu\text{g/L}$ at the six stations, all well below the 15 $\mu\text{g/L}$ criteria.

Total recoverable metals (Table 13) exceeded State water quality criteria at both control and outfall stations for copper, mercury, and nickel. Antimony, arsenic, beryllium, cadmium, chromium, lead, selenium, silver, thallium, and zinc did not exceed criteria. Previous studies (KLI, 1989) have indicated that the exceedence of water quality criteria is due to the specified test method in conjunction with high amounts of suspended particulates in Cook Inlet. Total recoverable metals criteria are generally exceeded for chromium, copper, mercury, nickel, zinc, and occasionally, lead. All of these metals were found to drop substantially in concentration when subjected to filtering, indicating that the high concentrations of metals are due to particulates. This is substantiated by reviewing the TSS values presented in Table 13, where higher TSS values typically correspond to the high total recoverable metals concentrations. Dissolved metals were all below the receiving water standards for all samples (Tables 13 and 18).

Cyanide samples met State-specified criteria of 2 $\mu\text{g/L}$ which is the water quality standard for marine aquatic life. Cyanide samples collected during the receiving water sampling were all below the detection limit of 2 $\mu\text{g/L}$.

In summation, statistical analyses of the 1998 receiving water quality data indicated that water quality outside either the EPA or State-specified mixing zones was not degraded with respect to control stations for most parameters. Most differences that were noted could not be directly attributed to the Point Woronzof outfall.

5.2.2 Intertidal Bacteria Comparisons

The ADEC has indicated that their primary concern is bacterial contamination of the shoreline by the Point Woronzof discharge, indicated by fecal coliform bacteria concentrations. Because the Knik Arm's water uses have not been classified, regulations provide that the most restrictive standard must apply. Therefore, the fecal coliform receiving water standard that must be met is a median of 14 FC/100 mL (harvesting for consumption of shellfish) with less than ten percent of all samples exceeding 40 FC/100 mL (contact recreation). The first standard protects the use of harvestable shellfish beds. In fact, no harvestable shellfish beds occur in Knik Arm because of the naturally high suspended solids. Therefore, use of the 14 FC/100 mL standard is very conservative and exceeds the limit required to protect actual use. The second standard is for contact recreation (swimming, water skiing, etc.). In fact, limited contact recreation takes place in Upper Cook Inlet. People walk on the beaches and view the Inlet, but these activities classify the Inlet's use as "secondary recreation" where higher limits would apply.

Levels of fecal coliform bacteria in the effluent, area creeks, and stations sampled during the August intertidal field survey are provided in Table 15. The range of fecal coliform concentrations for all intertidal samples collected during 1997 was 2.2 to 23.0 FC/100 mL, with a median of 9.2. This is compared to the most restrictive water quality criterion of a median of 14 FC/100 mL. One value of >16.0 FC/100 mL was reported at Station IT-5, southwest of the diffuser. The highest coliform concentrations at or above 16 FC/100 mL were reported at Stations IT-1, IT-3, and IT-5. Some of these high concentrations may be the result of heavy waterfowl use of the area (refer to Figure 3 for station locations). The criterion of not more than 10% of the samples exceeding 40 FC 100/mL was met. The fecal coliform concentrations in the effluent samples collected in conjunction with the receiving water, intertidal station, and stream sampling were reported as >16.0 and 140 (duplicate sample) FC/100 mL. Concentrations in the creeks samples at the same time ranged from 23.0 to 300 FC/100 mL.

No State water quality standard exists for enterococci bacteria concentrations. Concentrations at all the intertidal stations ranged from 1.0 to 6.3 MPN/100 mL (Table 15). Stations IT-1 (Replicate 2) and IT-C4 (Replicate 2) showed the highest values of 6.3 MPN/100 mL. Concentrations in the three creeks that were sampled ranged from 4.1 to 204 MPN/100 mL. The effluent enterococci concentration was >2419.2 MPN/100 mL for both replicates.

In summary, fecal coliform samples collected at the intertidal stations met the most restrictive receiving water standards. The median of the intertidal samples was less than the State-specified limit of 14 FC/100 mL, and the criterion of not more than 10% of the samples exceeding 40 FC 100/mL was met. Area creeks again showed the highest fecal coliform and enterococci concentrations of most of the intertidal or receiving water stations, indicating that receiving water concentrations may be influenced by runoff from these creeks.

6.0 CONCLUSIONS

The following conclusions were based on results from the thirteenth year of monitoring:

- The influent, effluent, and sludge monitoring has shown that, with few exceptions, the Point Woronzof facility is meeting the NPDES Permit requirements and is complying with State of Alaska water quality standards. MOA's self-monitoring of flow rate, pH, total residual chlorine, and total suspended solids showed compliance with Permit effluent limitations.
- Arsenic levels in the influent, effluent, and sludge in 1998 were slightly elevated compared to the years prior to 1992, but were lower compared to 1992 through 1994. Slightly elevated levels in the sludge in 1998 were attributed to one anomalously high value. Arsenic levels are not a concern at this time, since the maximum effluent concentration for 1998 was approximately 2,000 times lower than the MAEC.
- Total hydrocarbons in the effluent as oil and grease (SM 503B) exceeded the MAEC (375 $\mu\text{g/L}$) during the Summer-dry and Summer-wet toxic pollutant and pesticide sampling. These high levels are mainly due to test methods that analyze for oil and grease and were required by the State at the time of the Permit issuance. These methods are not a true indication of hydrocarbon levels and have been replaced by more appropriate methods in the new State of Alaska Water Quality Standards. Use of the more appropriate GC/MS aliphatic and PAH hydrocarbon methodology indicated that effluent hydrocarbon concentrations were less than the MAEC. In addition, total aromatic hydrocarbon effluent concentrations were below the MAEC (250 $\mu\text{g/L}$) for all samples.
- Fecal coliform did not exceed the monthly criteria "that not more than 10% of the effluent samples shall exceed 2600 FC MPN/100 mL during any month" of the reporting period. In addition, the maximum geometric mean of 850 FC MPN/100 mL was not exceeded. Fecal coliform concentrations in the effluent were lower in 1998 than those reported over the history of the program.
- The BOD₅ daily maximum criterion of 140 mg/L was exceeded three times during the reporting period. The weekly average BOD₅ criteria of 130 mg/L was never exceeded during this report period. The monthly average criteria of 120 mg/L was exceeded once during the reporting period.
- Percent removals for BOD₅ (54%) and total suspended solids (80%) were considerably better than the 30% required by the amendment to the Clean Water Act (40 CFR Part 125; Final Rule, 8/9/94). Based on data from the last seven years of the program, BOD₅ and total suspended solids removal rates of at least 30% should not be a concern in the future.
- To test the hypothesis that the water quality at the ZID boundary was not degraded with respect to the water quality at the nearfield and control stations, statistical comparisons were employed. No statistically significant differences were found which could be directly attributed to the Point Woronzof discharge.

- Fecal coliform concentrations were significantly different when the outfall stations were compared to the control water quality stations, however, median fecal coliform concentrations at the outfall stations, including both within the mixing zone (within ZID and ZID boundary) and nearfield stations, met the State criteria of 14 FC/100 mL. The criterion of not more than 10 percent of the samples exceeding 40 FC/100 mL could not be assessed. Area creeks again exhibited fecal coliform concentrations far in excess of those seen in the receiving water and intertidal stations.
- Enterococci bacteria counts were relatively low, but significant differences were seen between the outfall area (State-specified mixing zone) and the nearfield stations as compared to the control stations. Area creeks exhibited enterococci concentrations higher than all water quality stations and intertidal stations.
- Intertidal fecal coliform concentrations along the beaches near Point Woronzof met the most restrictive State water quality criteria median of 14 FC/100 mL for "harvesting for consumption of raw mollusks or other raw aquatic life". Since the Upper Cook Inlet is unclassified under ADEC's water quality standard, the most restrictive criteria apply, although no shellfish beds exist in the vicinity. The criterion of not more than 10% of the samples exceeding 40 FC 100/mL was also met. The fecal coliform concentrations in area creeks was elevated, exceeding that of the intertidal and receiving water sample results.
- Total residual chlorine were at or below the detection limit of 0.005 mg/L. Exceptions were noted mainly at the within ZID and ZID boundary outfall stations; however, one TRC value above detection limits was seen at a control station as well as a nearfield station. The average TRC concentration in the effluent during the receiving water sampling at the outfall was 0.8 mg/L.
- Supplemental receiving water quality samples obtained as part of the plume dispersion monitoring indicated that background levels of dissolved metals were all below the State water quality standards. Total recoverable metals exceeded the standards at both control and outfall stations for copper, mercury, and nickel. With the exception of dissolved arsenic, copper, nickel, and lead, no significant differences between the outfall and control stations were found for either dissolved or total recoverable metals. Even though significant differences were seen between the control and outfall stations in these four dissolved metals concentrations, all concentrations were well below State water quality standards.
- Supplemental receiving water samples also indicated that total hydrocarbons, measured as aliphatic hydrocarbons, did not exceed the State's water quality standard at any outfall or control stations. Total PAH did not exceed the State-specified limits for total hydrocarbons. Total aromatic hydrocarbons (EPA Method 602) also met State-specified levels at all stations. No significant differences were found between concentrations at the control and outfall stations for any hydrocarbon analyses with the exception of coprostanol and cholesterol, two sterols that are known to be associated with primate sewage.
- Sampling approach and methodologies for the water quality monitoring program are both addressing and satisfying the objectives outlined in the existing Permit, with the few applicable exceptions listed above.

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